A professor is always happy when he sees one of his students proceed farther and higher than himself.—EDMOND FRÉMY. (See p. 705.)

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SCHOOL SCIENCE
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VOL. XLIX DECEMBER, 1949 WHOLE NO. 434

REACTIONS OF TEACHER TRAINEES TO EDUCATIONAL JOURNALS

G. D. MCGRATH
University of Illinois, Urbana, Ill.

Much evidence is available to indicate that educational journals, in general, have vastly improved during the past decade and that they render significant service to those interested in the training of teachers. A tragic note is inserted into the picture when it is learned that so many of our teacher trainees know practically nothing of what is available in the literature which is of help in improving classroom teaching. Thousands of experienced teachers have their first functional contact with educational periodicals in a graduate level methods or research course. These graduate students evince surprise when they learn that so much of help is contained in current and in fairly recent volumes of educational magazines, and adamantly proclaim the fact that such materials would have been of inestimable help in their first years of teaching. As partial substantiation of this, the current writer has had occasion to learn something of the opinion for and of the utilization of educational journals by over 650 graduate students enrolled in methods courses offered by the education department in some state universities. There was convincing testimony to the fact that educational journals are not used by classroom teachers to the extent which would be normally anticipated.

The current writer had occasion to conduct a minor investigation with respect to evaluation and preparation of critiques of educational journals by teacher trainees. The number of teacher trainees included in the survey was 476, and 51 educational periodicals, in addition to 45 state education association magazines, were considered. Each trainee applied criteria of evaluation which had been formulated via seminar approach and made recommendations for improvement of

educational literature. Each trainee evaluated approximately ten educational magazines.

The purpose of the study was to further acquaint teacher trainees with educational literature and to gain from them reactions and opinions about values to be gained through perusing or reading the magazines as well as suggestions for improvement of their services.

The critiques or evaluations and the suggestions or recommendations were analyzed and tabulated so that all statements which bore a similar connotation were coalesced into one general statement. The suggestions and general reactions thus combined are presented herewith:

1. There is quite ample variety among professional educational magazines with adequate division of function—i.e.—field magazines as illustrated by one devoted to teaching of chemistry, appropriate area magazines as illustrated by those especially for secondary education, and others with general or special functions.
2. Education magazines, in general, do an excellent job of preparing materials in attractive and interesting format.
3. There is great need for a teacher education journal devoted to problems of preservice training of teachers.
4. Several magazines should devote special issues occasionally to teacher education problems, as well as special issues to other special educational problems.
5. Magazines should devote more space to practical suggestions for new teachers, including review of educational wisdom of past decades and current practices of promise in other countries.
6. When an especially good article is included in some more obscure journal, other magazines should summarize or reprint it after obtaining proper permission.
7. Educational journals should include frequent bibliographies or topical summaries which show trends of general interest in teacher education and in various fields or areas of classroom teaching.
8. Educational journals should frequently summarize newer instructional trends of promise through digests and abstracts.
9. Educational journals should keep teachers informed about the work and progress of special committees, commissions, and groups attacking significant problems of education.
10. Educational journals should make special effort to tap the illimitable reservoir of contributions possible if worthwhile ideas and techniques of masses of teachers were presented. More en-

couragement is needed to stimulate teachers to write up ideas, methods or experiences for the literature.

11. More educational journals should include more pictures and illustrations of schools in action.
12. Educational journals should present points of view on controversial issues, on theoretical philosophy, and on functional approaches to problems in education.
13. State education association journals should be made available for trainees to peruse and locate interests.
14. Educational journals should actively promote research and experimental programs in teacher education.
15. Educational journals should serve as media of communication for newer instructional practices of promise.
16. Educational journals should give more emphasis to improvement of methodology and the art of instruction.
17. Educational journals should stress shorter articles with conciseness and clarity and thus permit a greater or broader coverage by including more articles.
18. Educational journals should present question corners and introduce readers constantly to prominent educators.
19. Educational journals should emphasize simple, sincere, helpful materials rather than the deeply profound treatment which has a very limited reader audience.
20. Educational journals should appeal to the vast numbers of teachers and not to a limited professional elite.
21. The materials of *all* educational journals should be indexed in various professional indexes or reader guides.
22. Educational journals should be used heavily in conjunction with education courses in the preservice training of teachers.
23. Young educators should insist that Boards of Education provide an ample professional shelf of educational magazines for teachers to use.
24. Teacher trainees should be required to conduct integrative research in appropriate journals in their special fields of interest.
25. Educational journals should frequently sample reader opinion, including the potential audience among teacher trainees, in order to better meet the needs and interests of reader clientele.
26. Educational journals should see to it that no worthy cause in education lacks a champion.

It is admitted that there is little of new or unexpected concept as a result of this inquiry. It is also apparent that opinions of the trainee may not be as mature and important as those of the experienced teacher. It is submitted, however, that teacher training institutions

need to make certain that maximum utilization of educational journals is made in their programs and that the magazines are readily and abundantly available.

Educational journals are doing a good job, and we need to help them to maintain such high standards by promoting the best uses of them. We can depend on the journals to constantly attempt to improve and to meet our needs as long as we stimulate active use of them by our trainees and professional staffs. An excellent opportunity for cooperative teamwork is thus provided inasmuch as many of the consumers of magazine materials are also the contributors of other magazine material. We should not overlook any possibilities of assisting our educational journals to serve us better and more adequately.

A HALF CENTURY OF TEACHING SCIENCE AND MATHEMATICS

This brief statement introduces you to the title of our anniversary book. It is no longer a dream nor a plan, it is almost reality, for we hope to place the finished book into the hands of our members by early fall of 1950, our great anniversary year.

The pages of this book will relive for us an important half century of teaching and the part which our organization played in that period. It will be educational as well as inspiring to read these pages of tribute to the 50th anniversary of CASMT.

The cost of the attractively bound book will be $3.00. We offer, however, a pre-publication order for $2.50, which can be sent to our financial secretary, Ray C. Soliday, between now and September 1950. During the early part of 1950 publicity material on the book and an order blank will reach every member of our organization. Orders placed well in advance of the publication date will be a distinct aid to the committee in charge of publication.

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J. E. POTZGER, *Chairman*
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A STUDENT'S APPROACH TO MECHANICS*

PERCY F. BENEDICT
Tilton School, Tilton, New Hampshire

FOREWORD TO THE TEACHER

Physics has been called the most typical of sciences, in that the facts of inanimate nature are experimentally observed, laws are developed to classify and coordinate the facts, and theories are expounded to explain the laws. From a relatively compact group of assumptions, axioms and definitions, the explanation of all the facts is logically built up by reasoning. Yet as commonly taught at the high school level, such an approach is seldom even approximated. In too many textbooks, laws and theories are laid down for the learner to believe, in somewhat the same way as an Arabian is expected to believe the tenets of Mohammed. It might be called descriptive indoctrination.

The list of observable facts from which Newton derived his laws of mechanics probably comprised no more than the following: (a) motion caused by gravity, such as balls rolling down grooves, (b) motion caused by gravity, such as two slightly unequal masses suspended from the ends of a cord passing over a pulley, (c) impact, as with two or more balls suspended in a row from cords, (d) planetary motion as expressed by Kepler's laws. Long after Newton the torsion balance experiment was devised by Cavendish, but it is much too delicate for student use. Additions to this brief list have not been made, except for variations, for 150 years. It is a handicap that high precision in laboratory demonstrations of mechanics is impossible because of friction.

As teachers, we are able to come close to the inductive approach in calorimetry and geometrical optics, but have been far from it in the more underlying topic of mechanics. The following paper is written for, and at the level of, twelfth grade boys. Selecting one of the most treacherous topics in physics, the distinction between the pound of force and the pound of mass, with the derivation of $F = ma$, it suggests a scheme of activities from which the learner can inductively organize the subject for himself. It presents unusual and improved ways of thinking about important concepts. It discards the poundal of force for the realistic and sufficient reason that it is never used outside a schoolroom, and because one can show a youngster a slug of mass. The slug might be made an "absolute" fundamental unit

* Condensed from portions of a thesis submitted in partial fulfillment for the degree Ed.M., Boston University, August 1948. The abridgment should not bother the experienced reader, though the beginner may find some of the paragraphs need amplification.

and the more elusive concept of the pound of force becomes a derived unit. The loose and ambiguous "definitions" that "energy is the capacity to do work" and that "force is a push or pull" are avoided. Kinetic energy $\frac{1}{2}mv^2$, instead of following $F=ma$ as in most texts, precedes it. Although such inherent difficulties for the beginner as the vector mathematics involved in velocity and acceleration are omitted, yet a rigorous treatment could be written along similar lines.

Matter

The most obvious physical fact is the existence of matter as recognized by our senses of sight, touch and smell. It may be said by way of description, rather than as an attempt to define the indefinable, that matter occupies space and responds to gravitation or earth pull. One kind of matter may be distinguished from another by physical properties, such as color, flexibility or hardness, or by such characteristics as that some kinds of matter may become magnetic or luminous.

The term used in measuring whether one object has more matter than another is *mass*. Quantity of matter is manifested in more than one aspect, the simplest approach being an examination of the gravitational aspect. For example, if two blocks, say one of iron and one of magnesium, just equalize each other on a balance, Fig. 1, they have the same mass, that is, the same amount of gravitational attraction. With this device, if two such blocks, proved to be of equal mass,

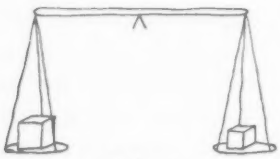

FIG. 1

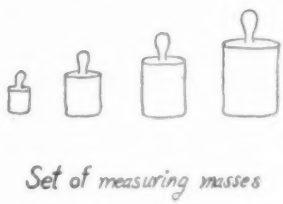

FIG. 2

are both placed on one pan, then a heavier block may be placed on the other pan and adjusted in content by adding or removing material until balance is obtained, when it will have twice the mass of either of the first two blocks. By continuing such a process a standard set of measuring blocks, Fig. 2, may be made up, having masses in convenient multiples of each other, and used for measuring the masses of any other object.

Space

The existence of space up and down, ahead and behind, to the right and to the left, is axiomatic, that is, the idea is accepted without proof. It is evident that there are great units of space between the earth and

the moon or stars, and small units of space between grains of powder. Space is recognized as length in lines having one dimension, as area in surfaces having two dimensions, and as volume in objects having three dimensions.

The term *density* is an example of a concept which is not axiomatic, for it is definable in terms of volume (length cubed) and of mass. It is used to specify whether a given kind of matter is heavy or light. By way of illustration, wood will float on water because it has less density than water, The density of any specimen may be computed by dividing its mass by its volume. A convenient unit of density is pounds per cubic inch.

Energy

Although it cannot be seen, felt, or measured in any direct way, there is probably no concept in physics or chemistry more important than that of energy. Every variation in the properties of matter is to be attributed to an energy change. There are many ways of changing the physical and chemical properties of matter. Water will change to ice if placed in a refrigerator, a rod of malleable iron will become magnetic and pick up tacks if a permanent magnet be brought near it, a platinum wire will become luminous if held in a gas flame. These are examples of physical changes because the identity of the substance is not lost. Usually physical changes may be reversed more or less easily.

On the other hand, a change which produces a different substance is known as a chemical change. For example, if white crystalline sugar be put on a hot stove it turns to a brown liquid and, with further heating to a black solid which even the most skilful chemist could not easily return to the usual form of sugar.

Energy exists in several forms, the most common of which is heat (thermal energy). Kinetic energy accompanies motion, and is possessed by any moving body. Chemical energy is intimately bound up in the structure of matter and is often released in the form of heat during a chemical change. Radiant energy from the sun warms objects on the earth.

There are numerous ways of converting energy from one form to another. For example, kinetic energy is frequently converted to heat by friction. Engineering and physics are largely concerned with the conversion of energy from one form to another. A good illustration can be found in the steam power plant, where the boiler converts chemical energy from coal into heat energy in steam. The boiler supplies steam to an engine which converts the heat into rotational kinetic energy of the shaft. Attached to the revolving shaft may be an electric dynamo which affects further conversion. Energy may be

usefully obtained from waterfalls, from burning coal, from electric batteries and from muscular effort.

Fields of Energy—Attraction

Numerous instances may be cited in which properties are exhibited by a group of two or more bodies depending on their size, shape and relative position. One such property is that of attraction, and a phenomenon closely related to it called a field of energy. An instance of

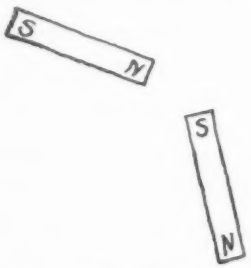

Fig. 3

attraction is that of magentism. Bar magnets of hardened steel are familiar objects, and it is well known that the two ends appear to be opposite in certain respects, so that one end is often marked *N* and the other *S* (north seeking and south seeking if suspended so that the bar can swing). With two such magnets, if they be placed in the position shown, Fig. 3, there is an attraction between the two nearest ends. In explanation of this phenomenon, it is said that a field of energy exists in the space surrounding the magnets, and iron filings are often used to demonstrate the shape of this field. Part of the evidence that the field surrounds the magnets is that if, while the two magnets are held in the position shown, a metal wire be passed through the space between, though without touching either of them, an electric voltage-drop may be detected in the wire.

There is a still better known instance of attraction, namely that of gravitation. It seems to be an outstanding property of mass that any body attracts any other, the intensity of attraction varying with size, shape and relative position. Newton announced this as the underlying principle of the solar system in 1672. Between two objects in a laboratory the attraction is extremely slight, but in 1797 Cavendish devised apparatus with which he measured the attraction between gold and lead spheres. There is mutual attraction between the earth and any ordinary object, but the earth is so very large in relation to all bodies in human experience that no one is conscious of any effect on the whole earth, but only of attraction toward the earth. A field of gravitational energy surrounds the earth. The energy stored

in this field is increased and a force must be exerted when any object is lifted to a higher elevation, and the energy is diminished if the object is lowered again. An example is the tall clock with the weights that wind up. The descent of the weights supplies energy which keeps the clock going, and when the weights are all the way down the clock stops.

Elastic energy is a form which is due to shape and relative position. A watch is driven by a spiral spring. By winding up the spring the shape and relative position of the coils are changed, and elastic energy is stored which is gradually used to overcome the friction of the running of the watch.

Order of Forms of Energy

Among the various forms of energy, some may be considered to be of a higher order than others. In the case of the more highly ordered forms the amount of energy depends on the size, shape and relative position of the bodies or particles concerned, that is, on geometrical arrangement. For example, when an iron piece is close to a magnet the attraction is much greater than when it is removed even a moderate distance. Shape and relative position are significant in the gravitational and elastic forms where energy appears to be most highly ordered, and to have a spontaneous tendency to convert to the less highly ordered forms. The kinetic form is intermediate, and depends on ordered motion of a body. Thermal or heat energy is the lowest form, and depends on random, that is, quite disordered motion of molecules.

The higher forms of energy convert to the lower forms through the intermediate forms. For example, the natural tendency of gravitational or elastic energy to convert into the lower form of heat energy takes place by way of kinetic energy. Force is a phenomenon often accompanying such conversions of energy. Among the more familiar forces are those due to gravitational attraction toward the earth, to muscular exertion, and to friction.

As an example of the attraction of gravity being a force which exists during a conversion of energy from gravitational to kinetic, consider a block sliding down a smooth incline onto a rough hori-

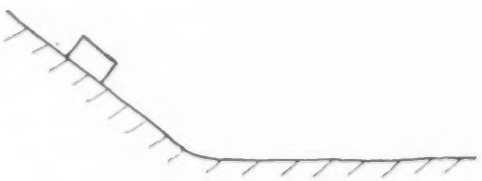

Fig. 4

zontal surface, Fig. 4. While the block is sliding down the incline the *force of gravity* moves it, and gravitational energy is being converted into kinetic energy. While the block is coming to rest on the rough surface, the force of friction stops it, and kinetic energy is being converted into heat.

Force

All forces are due either to attraction or repulsion in a field of energy, or to a conversion of energy such as the instance of the sliding block. The existence of a force requires the influence of another body. The concept of force then implies the mutual action of two bodies, hence forces always exist in equal and opposite pairs (Newton's third law).

It is believed that the gravitational fields of planets smaller or larger than the earth have corresponding less or greater intensity than that of our earth. For example, on the smaller planet Mars a given body at an elevation of 2,000 feet above the ground stores less gravitational energy than the same body at an elevation of 2,000 feet above the surface of our earth. In such a case the mass has not changed nor has the elevation, but the amount of gravitational force has changed. Hence it can be readily seen that the amount of gravitational energy stored in the field by lifting a body equals the force (not the mass) times the difference in elevation.

Consider the effort to pull out a coil spring, Fig. 5. The greater the effort exerted to extend the spring, the more its shape and the relative position of its coils are changed. Beginning from the free or relaxed position, more and more elastic energy is stored in the spring as it is stretched, but this conversion of energy is reversed when the spring returns to its relaxed shape, If apparatus consisting of a spring with a mass hanging from it were moved from sea level to the top of a

Fig. 5

mountain a difference of about $\frac{1}{2}$ of one per cent in the reading of a scale marked alongside the spring might be detected. But if an equal arm *balance* be carried from one such locality to another, no variations are observed in the masses measured by it. Hence it may be seen that only the force is changed.

The unit of energy in the gravitational or elastic forms becomes the *foot-pound* (meaning feet times pounds), the pound being the unit of force. Balances and spring scales actually measure the force of gravity on a body, although they are commonly supposed to measure mass, that is, quantity of matter. In the later paragraph on Inertial Mass the important distinction between the concepts of force and of mass will be emphasized.

Fundamental and Derived Quantities

All quantities in mechanics may be derived from three fundamental ones, mass and length which have already been introduced, and *time*. Everyone is conscious of the progress and duration of time. It cannot be explained in words having any simpler significance than time itself. It goes always forward in human consciousness.

The derivation of the quantities force and energy from mass, length and time is somewhat roundabout, and through several following paragraphs the necessary ideas will be built up to make this derivation. But among readily derived quantities, it has already been shown that density is derived from mass and length. *Velocity* is a useful quantity which may be derived from length and time, and conveniently expressed in feet per second. Often the motion of a body is such that the velocity is sometimes faster and then slower. but in any case the average velocity is computed by dividing the distance s (in feet) by the time t (in seconds).

$$v = s/t$$

Motion Due to Gravity

The force of attraction of gravity is an important cause of motion. For a thousand years before Galileo it was supposed that the heavier an object was, the faster it fell. But in 1590 he released objects of different masses simultaneously from the leaning tower of Pisa, and showed that the heavier and the lighter struck the ground nearly together. In general, the speed of a falling object becomes faster and faster the further it falls. However air friction, which is zero when there is no motion, becomes greater and greater the faster the motion. When falling from a sufficient height, a body reaches a limiting speed where the attractive force of the earth urging it to greater speed is balanced by the resisting friction of the air. In the case of fine rain

drops this limiting speed is quite low. For hail stones it is a higher speed. Unfortuantely it is impossible to make precise measurements with balls falling through the air, or rolling down grooves, because friction can never be entirely eliminated, but in this immediate discussion it will be assumed that friction can be neglected.

By dropping stones from points higher and higher up a tower or cliff, and measuring the time to hit bottom, it is found that a stone falls nearly—

16 feet during the first second

64 feet during the first two seconds

144 feet during the first three seconds.

The striking fact about these figures is that the distance fallen equals the square of the number of seconds times the number of feet fallen during the first second. That is, simple algebraic relations may be shown to exist by arranging the figures as in Table 1. Using h = height

TABLE I

Col. 1 Elapsed Time Seconds	Col. 2 Total Distance Fallen Feet	Col. 3 Total Time by 16	Col. 4 Distance Gained Each Second	Col. 5 Average Time by 32	Col. 6 Velocity Gained Each Second
0	0				
			$16-0=16=32\times0.5$		
1	$16=16\times1^2$				$48-16=32$
			$64-16=48=32\times1.5$		
2	$64=16\times2^2$				$80-48=32$
			$144-64=80=32\times2.5$		
3	$144=16\times3^2$				$112-80=32$
			$256-144=112=32\times3.5$		
4	$256=16\times4^2$				$144-112=32$
			$400-256=144=32\times4.5$		
5	$400=16\times5^2$				

in feet, t = time in seconds and v = velocity in feet per second, column 3 gives $h=16t^2$, and column 5 gives $v=32t$. By algebraically eliminating t between these two relations, an important connection may be obtained between v and h. That is

$$v^2=64h \qquad \text{or} \qquad v=8\sqrt{h}$$

Now if experiments be devised to measure the speed of an object sliding or rolling along an inclined path, straight or in any smooth curve, it is found that, in whatever direction the path carries the object, the velocity depends only on the vertical distance down from the starting point where the body was at rest. In other words provided h be always measured vertically, the velocity acquired by a body

falling without friction through moderate heights is $v=8\sqrt{h}$. This does not depend on the quantity or kind of mass, nor on the shape of the path. It is an important relationship because it is one of the relatively few experimentally observable facts on which the laws of mechanics are based.

Acceleration

This is defined as the rate of change of velocity, that is (for the simple case of motion in a straight line starting from rest), if v is the velocity attained in t seconds, the average acceleration is

$$a=v/t$$

(It should be noted that v in this expression is the final velocity, while v in the expression $v=s/t$ is an average velocity.)

Returning to the case of the freely falling body, in Table 1 significance was attached to the arithmetical difference between successive figures. If this method of differences be carried further, an interesting result occurs, for in column 6 the differences are constantly 32. Thus the acceleration of a falling body is 32 feet per second in each second. This is called the acceleration of gravity, and the symbol g is used to represent it. The value of g is not exactly 32, there are small variations in it from one locality to another, and it diminishes slightly at altitudes of 2 or 3 miles. Ignoring such variations, the previous relation $v^2=64h$ may be written $v^2=2gh$. The corresponding relation for any uniform acceleration, as for a train starting up or for a ball rolling down an inclined groove, using the symbol s for distance covered, becomes

$$v^2=2as.$$

Impact

Experiments on impact, or the hitting of objects together, reveal underlying principles of mechanics. Apparatus may be set up in a number of ways, for instance by suspending two balls of elastic material such as steel or ivory from cords so that they may be drawn aside

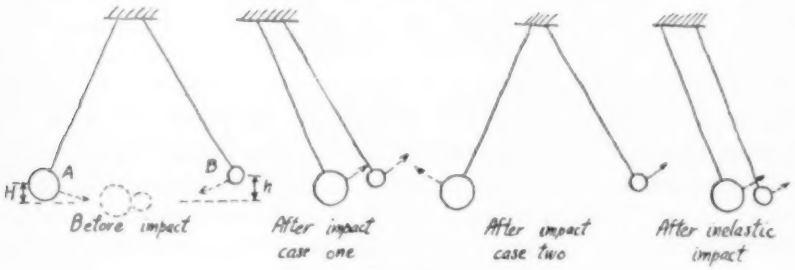

Fig. 6

and released to swing and hit each other. Depending on their relative masses, and the relative heights from which they are released, the balls after impact may both swing in the same direction (case one in Fig. 6), or in opposite directions (case two). If the balls are of inelastic material, they both move together after impact. The velocity of a ball at the lowest part of its swing may be readily computed, using the height h (in feet) from which it starts, that is, $v=8\sqrt{h}$ feet per second.

Consider the case of two balls of lead or clay, that is, of inelastic material. When adjusted so that they will strike each other centrally, it is possible by trial to select pairs of points, indicated by A and B in Fig. 6, such that if the balls are released from these points, they bring each other to rest when they strike.

By the time Newton announced his laws of motion, it had been learned that such experiments may be formulated by defining a quantity called *momentum* as the product of the mass of a moving body and its velocity. When impact brings two balls to rest, if M and V are the mass and velocity of one, and m and v are the mass and velocity of the other, and H and h are the heights from which they start, then the experimental measurements show that

$$M\sqrt{H}=m\sqrt{h}.$$

But substituting the relations $V=8\sqrt{H}$ and $v=8\sqrt{h}$, this reduces to

$$MV=mv.$$

For most cases of impact of two balls, both balls will be moving after impact. Just as the velocity of a ball before impact may be measured by the height from which it starts, so the velocity after impact may be measured by the height to which it rebounds. Such measurements show that the sum of the momentums before impact equals the sum of the momentums after. (It should be realized that momentum is positive in one direction, let it be to the right, and negative in the opposite direction, to the left.) This is an instance of what is called conservation of momentum.

Kinetic Energy

It is found that the concept of momentum is sufficient to explain impact of inelastic bodies. But Huygens in 1699 published a study showing that during impact of highly elastic bodies another quantity besides momentum mv is involved. This additional quantity he expressed as mv^2, and it became one of the earliest notions of what is now called kinetic energy and written $\frac{1}{2}mv^2$. The one-half was not put into the expression for more than a century, because an equation

between energy before impact and after impact balances without the one-half on both sides.

Just as momentum is defined as mass times velocity, so kinetic energy may be defined as momentum times velocity. Now a body cannot pass instantaneously from a state of rest to a state of motion, time being required while it acquires velocity (even though during impact this interval of time may be very brief). Therefore during a change from rest to motion the average momentum is one-half the final momentum. When this is multiplied by velocity the expression for the kinetic energy U becomes

$$U = \tfrac{1}{2}mv^2.$$

A convenient example of acquiring kinetic energy by a mass is a body falling without friction, for the gravitational energy due to its elevated position is converted into kinetic energy of motion. Now within moderate heights above sea level, difference in gravitational energy for a given body depends only on difference in its elevation from one position to another. It has already been shown that the square of velocity likewise depends only on difference in elevation, and that gravitational energy equals force times difference in elevation. The relation for energy converted from gravitational to kinetic therefore becomes

$$Fh = \frac{mv^2}{2}.$$

Since the unit for gravitational energy is the foot-pound (the pound being the unit of force) the unit for kinetic energy may also be the foot-pound. In general, for any force due to a conversion from kinetic energy, whether the body is moving vertically or in any other direction

$$Fs = U \qquad \text{or} \qquad F = U/s.$$

Hence *force* may be defined as the *space rate of change of energy*.

Since velocity is derived from length and time, the derivations have now been made for energy and for force in terms of the three fundamental quantities, mass, length and time, as promised several paragraphs back.

Inertial Mass

If algebraic substitution of $v^2 = 2as$ be made in the relation between kinetic energy and force, there results

$$Fs = \frac{mv^2}{2} = \frac{m(2as)}{2}.$$

Cancelling out s gives an important relation between force, mass and acceleration

$$F = ma.$$

When applied to a freely falling body so that $a = 32$ feet per second in each second, this gives $F = m \times 32$. The force exerted by gravity is measurable, and the term used in measuring it is the *pound*. But a force of one pound is not the same thing as a mass of one pound, as can be seen in the above equation, which does not balance when $F = 1$ and $m = 1$ because $a = 32$. The word *weight* is correctly used to mean the *force* of gravity on a body. Of course a body appearing to weigh one pound on our earth would appear on a spring scale to weigh much less than one pound on the planet Mars.

The use of the word pound as a unit both of force and of mass in studying mechanics is the cause of considerable confusion, and no ideal way has yet been devised to avoid it. The source of the difficulty is the two aspects of mass, gravitational and inertial, which are exactly proportional to each other according to all known experimental evidence. A body of matter stores energy in the gravitational field, it also acquires kinetic energy when set in motion. Inertia is the property of matter which resists any change in its state either of rest or of motion in a straight line. Probably the least undesirable way out of the confusion over the two 'pounds' in U. S. practice is the use of the familiar unit *pound* for the more subtle concept of force, and the use of *slug* for the unit of mass in any problem involving inertia, the slug being 32 pounds (more precisely 32.17 pounds). Then in the relation $F = ma$, when $F = 1$ pound, $m = 0.031$ slug and $a = 32$, the equation balances.

A unit of momentum is the slug-foot per second.

THE QUIZ SECTION

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1. A system of n equal masses is connected by $n-1$ light equal strings and lies on a smooth horizontal table. The first mass is gently dropped over the edge and the other masses are thus set in motion by successive jerks. Find the velocity of the last mass as it leaves the table.

2. An elastic string of modulus K and natural length L is stretched and its ends fixed at two points on a horizontal surface. A mass m is fixed to the *mid point* of the string. Find the period of oscillation along the line of the string.

3. In #2 find the period if the mass m is fixed to the string at a point one-third along the length of the string.

4. A bureau drawer of width w and length d has two knobs symmetrically placed at equal distances h from the sides. If the drawer is pulled by one knob only find the maximum coefficient of friction for the drawer not to bind.

DRAMATIC MOMENTS IN THE HISTORY OF SCIENCE

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Dramatic moments in the history of a science may entertain, instruct and high point that section of the story in which they are found. They arrest a fagging attention, relieve boredom produced by endless sameness and change the quality of interest by a touch of emotional glow. So why not an occasional bit of the anecdotal?

A minister of religion experimenting with a "burning glass" is unusual but when the particular time of that experimenting is reported to be as of Sunday it becomes almost sensational. The story has it that Pastor Priestly, on that Sunday, some one hundred seventy years ago, produced some bubbles of gas from a red powder, mercuric oxide, by heating it with the sun's rays focussed by a "burning glass." The dramatic moment came, however, when he "gratified (his) curiosity by breathing it." He says,[1] "(I) fancied that my breast felt peculiarly light and easy some time afterwards. Who can tell but that, in time, this air may become a fashionable article in luxury. Hitherto only two mice and myself have had the privilege of breathing it." Could some one have revealed, to this Sunday experimenting preacher, the countless ones in distress who have since been relieved from suffocation by oxygen tents he would have had a fuller appreciation of himself as a healer as well as a preacher. It may seem a far cry from his mice under a bell jar to our pressurized stratospheric constellation air service; but is it?

Tragedy sometimes crowds drama off the stage of life. Too frequently the picture of the French scholarly-public servant, Lavoisier, has been that depicting the French mob snatching him from his laboratory in order to make him the victim of the guillotine. More significant for scientific understanding, however, was the day he completed his repetition[2] of Pastor Priestly's experiment by producing oxygen from the mercuric oxide powder. Being a man of originality he did not do it exactly as did the Englishman. Starting with liquid mercury, under a bell jar of air, he heated and turned some of the liquid metal to the red powder. As the powder appeared some of the air disappeared. By more heat the powder was changed back to the liquid and the air was restored. He found that he never removed more than about one fifth of the air by exposing it to heated mercury.

We, standing at our vantage point some one hundred seventy years

[1] Alembic Club Reprints. No. 7. Page 54. University of Chicago Press. (1923).
[2] Findlaay, Alexander. *The Spirit of Chemistry*. Longmans Green Co., N. Y. (1930), pp. 143–145.

later, can credit that accomplishment, to some extent, with modern air conditioning. By merely varying the percentage and kind of atmospheric ingredients we attain safe anaesthesia, and get relief from the cramps for the deep-sea divers as they emerge from their deep-sea pressures.

Lavoisier's penetrating understanding translated the mercury-and-air and other experiments into a workable and predictable pattern of explanation applicable to all transformations since labelled combustion. Thus he came to be considered the father of chemistry.

Many of the dramatic occurrences in the story of science are associated with experiments involving gases. The part of oxygen in the establishment of order in the relationship of chemical processes has just been noted.

A story that always brings students to full attention is that of Humphrey Davy's disproof of Dr. Mitchell's nitrous oxide theory of contagion. At the age of eighteen years, in his attic bedroom-laboratory, he demonstrated the fallacy of that theory by: exposing wounds to the gas; placing animals in its atmosphere; and actually breathing it himself. About a year later, when he had more adequate facilities at the Pneumatic Institute, in a suburb of Bristol, England, he continued his nitrous oxide experiments. By inhaling it more extensively he learned, first hand, of its "pleasurable sensation" that led to "enthusiastic and sublime" emotions and its tendency to make him "laugh at those (about)." At a later time he tested its anaesthetic effect upon himself while he was in great discomfort from "cutting a wisdom tooth." An entry found in one of his notebooks suggests "it may probably be used with advantage during surgical operations."[3] History records, however, that forty odd years elapsed before that "advantage" was really tried in medical surgery. As most informed persons now know, it did ultimately attain wide use as an anaesthetic in tooth extraction and minor surgery.

Chlorine is another gas that has attained considerable nontechnical publicity. One of the most interesting incidents in its bid for student interest is that of its use in demonstrating liquefaction of permanent gases. As told by Dr. Paris.[4] "I found Mr. Faraday (in the laboratory of the Royal Institution) engaged in experiments on chlorine and its hydrate in closed tubes. It appeared to me the tube in which he was operating . . . contained some oily matter and I rallied him upon the carelessness of employing soiled vessels. Mr. Faraday, upon inspecting the tube, acknowledged the justice of my remark. . . . I was unable to remain and witness (his repetition of the experiment)."

"Early the next morning I received . . . the following laconic note:

[3] Kendall, James. *Young Chemists and Great Discoveries*. Appleton-Century. Pages 15–19. New York. (1934).
[4] Kendall, James. *Young Chemists and Great Discoveries*. Appleton-Century. Page 61. New York. (1934).

Dear Sir:

The oil you noticed yesterday turns out to be liquid chlorine.

Yours faithfully, M. Faraday."

Thus the world of science first learned of the successful liquefaction of a so-called permanent gas. Davy was not slow to follow Faraday's success by the application of that know-how to many other gases including nitrous oxide, hydrogen chloride and carbon dioxide. It was some years later, though, when that property of all gases, known as critical temperature, was established by Thomas Andrews as a criterion for determining the thermal limit for success in liquefaction of gases.

Davy corrected the mistaken idea that chlorine was oxygenated hydrogen chloride but was not successful in isolating fluorine. He had released the extremely active sodium and potassium but he, and many others, found that the element fluorine had chemical tricks not in the catalog of any other element. One writer has said: "The history of fluorine is a tragic record."[5] Davy was but one of a procession of laboratory investigators who failed to free and identify fluorine. No less than five of them suffered from poisoning from hydrogen fluoride and other gases evolved in their work and two died from such effects.

Never-the-less, Fremy and, later, his student, Moisson, continued the quest. So it is not surprising that when, on June 26, 1886, a gas appeared in Moisson's apparatus which caused elemental silicon to burst into flame (Moisson's novel test for fluorine) his name soon became known throughout the scientific world. It is reported that Fremy said, when Moisson's success was confirmed, "A professor is always happy when he sees one of his students proceed farther and higher than himself."

For fluorine, as for many other discoveries, practical utilization followed but tardily, some fifty years, after its isolation. Seemingly it took World War II to gear fluorine to industry and research in a generally acceptable manner.

Helium's entry into science's dictionary of elements has a number of excellent stories to its credit. Its name, (helios) sun element, suggests one. The astronomer, Lockyer, found some lines in the sun's spectrum that he could not account for so he postulated an element in the sun's atmosphere as responsible for them. Thus, for a period of twenty-six years, helium was a sort of hypothetical element in the sun but not known on earth.

It was Sir William Ramsay who brought helium down to earth. He was engaged in a study of the atmosphere for its rare gases, some of which he had already found. He had secured a sample of a gas which he thought was one of them called Krypton. He sent the sample to

[5] Weeks, Mary E. *The Discovery of the Elements.* Mack Printing Co., Easton, Pa. Page 266. (1933).

Sir William Crookes for a check of its spectrum. Crookes telegraphed his result; that the gas had the same spectrum as that found for helium by Lockyer. In other words Ramsay had revealed the sun element as an ingredient of earth's atmosphere. In writing the news to his wife Dr. Ramsay pronounced the news as "quite overwhelming."

A third story; the discovery of helium's presence in certain natural gases from Kansas petroleum and its eventual isolation upon a commercial scale, gives America a place in this element's history.[6] Two Kansas investigators, H. P. Cady and C. W. Seibel, merit credit for the discovery of a source of this gas and the techniques for its isolation from its mixture with other gases.

Helium's low density made it at once a competitor with hydrogen for filling lighter-than-air craft buoyancy bags. Its low solubility in the blood stream plus its high rate of diffusion qualified it for use by deep sea divers as they emerge from the deep to surface pressures. An artificial atmosphere with helium substituted for nitrogen has relieved them from the very painful "bends" which they formerly experienced as they left their diving suits.

James Harvey Robinson has said[7] "The (scientist's) ideal was . . . and still is to dehumanize scientific investigation as far as may be." Thus objectivity not subjectivity is emphasized as the desired pattern of the man of research. However, when the product of his objective, dehumanized endeavors is to be released to the general public Doctor Robinson suggests, "We must . . . resynthesize and rehumanize (our knowledge). . . . A book or article for the general reader . . . must enlist attention. This (attention) must not be assumed but must be wooed." In his catalog of ways of wooing attention he says, "The story form is very congenial to the human mind, and the logic of a narrative or tale is always the best and surest form of appeal."

The teacher of science in the high school or junior college is trying to reach a constituency not greatly different from Doctor Robinson's general public. Need it be noted that if narrative is "congenial to the human mind," dramatic narrative may be capable of endowing the congenial with emotional qualities? And "The emotional life of man is primary," says one[8] of our philosophers. At least a desire to know does not inhibit learning.

[6] Cady, H. P. *Ind. and Eng. Chem.* 30, 845–852. (1938).

[7] Robinson, James H. *The Humanizing of Knowledge.* George H. Doran Co., New York. Pages 34, 100–107. (1923).

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Have you renewed your subscription to SCHOOL SCIENCE AND MATHEMATICS for 1950?

YOUTH OPENS THE DOOR TO CANCER CONTROL

A Classroom Study Unit

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Introduction

Fear, ignorance, misunderstanding, and lack of appreciation of the effects of cancer have been generally responsible for its high death rate. This has made cancer America's Public Health Enemy #2, second only to heart disease as a cause of death. Every year approximately 200,000 people in United States die from the effects of cancer. While most of these deaths occur in the age group of forty to seventy, about three thousand die between the ages of five and twenty, for cancer is no respecter of age. Neither is cancer a respecter of tissue, as it may attack most of the organs of plants and animals.

Forty per cent of these deaths need not have occurred at all, for cancer is curable when discovered and treated promptly. But people are reluctant to seek information regarding cancer: For this reason distribution of literature and the open discussion of the symptoms and progress of the disease have been taboo among those of the age group most likely to be affected by it. This indifferent attitude of the adult has naturally impeded progress in the education of youth in the nature of the disease.

It therefore becomes the purpose of this unit of study to educate the youth of today to be afraid *not* to inquire into the cause and effects of cancer, and to correct any erroneous ideas they may have concerning this disease. For only by acquainting the youth of today with the pertinent facts of cancer and its treatment can we in succeeding generations hope to reduce the death rate due to this cause.

This teaching unit in cancer has been prepared primarily for those students who have taken or are taking Biology. It is hoped that those on the tenth, eleventh, and twelfth grade levels will be able to utilize it as a phase of their work in biology. The material is presented so that it can be taught as a complete unit on disease or in conjunction with any of the phases of biology to which it is related, such as cell structure, cell growth, life processes, etc.

While the outline does not include all of the material that could be assembled on cancer, it contains what is thought to be sufficient to present an all round picture of cancer information. The biology teacher may make use of that part of the unit which in his mind deserves the greatest consideration, or as much as time will permit.

Primary Objectives

1. To instill in the minds of students the fact that the susceptibility to cancer is universal; that it can be recognized by certain "danger signals."
2. To present scientific knowledge concerning the cause, treatment and effects of cancer in such a way as to do away with the student's fear, superstition and erroneous ideas concerning the disease.
3. To show that cancer can be cured completely in its early stages.
4. To stress the importance of periodic health examinations so that someone specialized in the recognition of signs of cancer will be be able to discover the disease while cure is possible.

Secondary Objectives

1. To acquire knowledge concerning cancer so that it will be understood as a natural phenomenon.
2. To familiarize the students with reliable and varied sources of information concerning cancer and its treatment; to teach them to differentiate between reliable and unreliable sources of such information.

Latent Objectives

1. To inform parents, relatives, and friends—through the students—of biological facts concerning cancer.
2. To urge them to apply this information to themselves and begin to weigh the "cure-all" information against that of a reliable physician.
3. To induce individuals in the age group of 40–60, where there is the greatest incidence of cancer, to have periodic health examinations.
4. To reduce the death rate from this cause by widespread dissemination and use of cancer information.
5. To inspire students to enter cancer research and through their efforts to accept the challenge to conquer cancer.

Biological principles involved in the study of Cancer

A. The unit of all structure is the cell.
   1. Normal cell growth (mitosis) produces normal body growth.
   2. Abnormal cell growth may result in benign or malignant tumors.
   3. Malignant tumors are cancers.

B. Continued irritation caused by chemicals, heat, friction, may result in abnormal cell growth.

C. Other contributory factors in the development of cancer are age, skin color, heredity, nutrition, etc.

D. The virus theory of cancer.
E. Cancer even in its early stages may be recognized by certain definite signs.
F. Early cancer is curable by one of three approved methods of treatment: radium, X-rays, surgery, or by a combination of the three.
G. Cancer education makes advancement in the treatment and cure of cancer possible.

History

Cancer is not a new problem in the history of mankind. We find mention of it made in the early writings of the Egyptians. It became even more common in the medical history of the Greeks, who are credited with giving it a name which was later changed by the Romans to the word "cancer" meaning "crab." Cancer has been the subject of observation from time immemorial, and of the most elaborate investigation by innumerable workers in recent years.

Nature of Cancer

The union of the egg and the sperm cell forms one cell which through normal growth begins to divide into two cells, and then continues to divide into many more cells under the control of the life processes and other bodily forces until maturity is reached. All normal cells are subject to this strict control throughout life. After the body reaches maturity it becomes the function of the cells to repair only those tissues which have become destroyed, and therefore further cell growth is held in check by the same body forces which activated the cells in growth.

Cancer is a general term to designate all malignant tumors. A cancer begins as a single normal body cell or group of cells which for some unknown reason starts to grow independently of the other body cells, substituting growth for work. The unknown mechanism which keeps normal cells from multiplying beyond their proper limits seems to have no control over growth of cancer cells. As the abnormal cell growth increases in size it causes trouble by interfering with the function of the other cells and tissues within its vicinity. As this mass of cell material continues to grow it breaks up and is spread to distant parts of the body. A cancer may spread through the body in three ways: (1) It may simply extend by growth into the surrounding tissues. (2) It may enter a blood vessel or a lymphatic vessel and grow along inside it. (3) Small particles may become detached and be carried by a blood vessel or lymphatic vessel to distant parts where it sets up secondary growths.

Approaches

1. Show motion picture "Enemy X"—16 mm. sound film for lay audiences. Film opens with "unknown killer stalking about the city." No mention of cancer until audience interest has been clinched. 10 minutes.
2. Study a raw egg as a model of a plant cell, and a boiled egg as the model of an animal cell.
3. Study under the microscope amoeba or paramecium undergoing simple division by fission.
4. Study under the microscope simple plant cells such as protococcus or spirogyra.
5. Observe fertilized frog or salamander eggs undergoing cleavage, segmentation, and those processes concerned with normal cell growth.
6. Through a microscope study the structure of an onion root tip showing normal cell division through mitosis, particularly observing the resting, prophase, anaphase, metaphase and telophase stages.
7. Observe cell structure under microscope showing normal tissue growth and malignant tissue growth.
8. Show motion picture "Living Cells," Lewis film—16 mm. 2 reels, 18 minutes, silent. First reel—Normal rat cells, living white cells. Characteristic structure and activity are shown very clearly. Second reel—Cancer cells; living sarcoma from connective tissue. Multiplying cells show "resting" nucleus, separation of chromosomes, reforming nuclei and daughter cells.
9. Show motion picture "In the Beginning."

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"Youth Looks at Cancer," Westchester Cancer Committee, Bronxville, N. Y.—pp. 1–7, incl.

Tumors

All tumors or abnormal new growths of the body are divided into two large groups, benign and malignant. Those called "benign" are, as the term implies, comparatively harmless, but the others are called "malignant" because of their disastrous effects upon the body. Benign and malignant tumors are alike in their disorderly growth and in their failure to serve any useful purpose in the body. In other important respects they differ widely:

(1) The benign tumor usually grows slowly. The malignant tumor (cancer) usually grows rapidly.

(2) The benign tumor merely pushes aside the parts which surround

it. The malignant tumor grows into the tissues about it and may destroy them.

(3) The benign tumor is self-contained and does not spread throughout the body, The malignant tumor has no self-limiting borders and almost always spreads to distant parts of the body.

(4) The benign tumor is dangerous to life only when growing in some vital organ, such as the brain. The malignant tumor is dangerous to life wherever it may grow.

Approaches

1. Show motion picture—"Living Cells"—Canti Film—16 mm. 2 reels. 20 minutes, silent. Results of radium emanations on various tissue cells.
2. As examples of benign tumors, observe harmless warts on hands and fingers.
3. Observe abnormal cell growths on plant and animal tissue in life.
4. Make a collection of plants or animals showing abnormal cell growth.

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Causes of Cancer

The exact cause of cancer is not known. The "Parasite" seems to be the cancer cell itself, and the cancer cell comes from a normal preexisting tissue cell. Some of the factors that influence the normal cell to take on unrestricted growth are being studied. Competent authorities at present hold the opinion that cancer is caused in the practical sense by various forms of chronic irritation to which the human body is exposed from the cradle to the grave. Striking practical examples of this principle are numerous: A cancer of the tongue or inside the cheek, for instance, is often found directly opposite a jagged tooth. Cancer is also found on the lip where a hot pipe stem habitually rests. In the female genital organs cancer is preceded in the majority of cases by some form of chronic irritation. Skin cancer has been developed through exposure to tar, pitch, petroleum, soot, arsenic, dye stuffs, paraffin, and other irritants. On the experimental side, cancer may be produced in animals and plants by chemical agents such as tar, or petroleum; by physical agents such as X-rays; by a thermal agent such as heat; by actinic agents such as the sun's rays; by a biological (bacterial) agent such as the larva of the cat tapeworm. On the other hand, there is no evidence that cancer is

caused by a single injury, a germ, or a blow. It has never been found to be contagious.

Approaches

1. Show "Living Cells"—Chambers film, third reel only—"The Growth of Cancer Tissue," about 10 minutes. Silent, 16 mm.
2. To induce tumor growth in plants or animals for class demonstration:
   a. Apply some lanolin or naphthaleneacetic acid or indolebutyric acid, with 100 parts of lanolin, to one side of the growing stem of a tomato plant.
   b. Apply some of the above mixture to the cut off stem of a red kidney bean seedling.
   c. Paint a part of the stem of a sunflower, castor bean, or tomato plant with a diluted tar or ammonia in water solution.
   d. Apply some tar product to a shaved surface of a rat or guinea pig.

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Other Contributory Factors

Cancer is known as a disease of adult life. About 90% of all cancer deaths occur after the age of forty years, 97% after 30 years. For cancer is generally, like old age, the result of the wear and tear of tissues due to the natural stresses of living. Therefore the removal of these abnormal cell masses at an early age will protect other areas at a later age. Cancer of the skin is found more often in people who

live in the country than in people who live in urban areas. In United States the reported death rate from skin cancer is higher in white people than in Negroes. It would seem from this that pigmentation of the skin exerts a protective influence from long exposure to the sun's rays.

Experiments with animals have definitely indicated that heredity is one of the important underlying factors in the growth of cancerous tissue. From this it would seem that a tendency to cancer is transmitted in some animals and can be determined experimentally by the Mendelian ratio. It is thought that since there is hereditary susceptibility there is also hereditary insusceptibility.

Approaches

1. Show the possible Mendelian ratio of skin color inheritance.
2. Show the possible Mendelian ratio of probable sucseptibility to cancer.
3. Show the possible Mendelian ratio of insusceptiblity to cancer.

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Signs of Cancer

With rare but important exceptions there is no pain in the beginning of any kind of cancer. One of the most important signs that calls attention of the individual to the cancer is an unusual growth which starts without any apparent cause, such as a small painless lump in

the breast; a mole or wart on a shoulder or hand which shows signs of change; a slight thickening of the tongue or lip.

Another common sign is an unusual discharge. A persistent discharge from the nose or a slight weeping of a sore on the face which does not respond to ordinary treatment may be due to a cancer. Unusual blood-tinged discharge from the reproductive organs of the female or from any body opening frequently gives warning of cancer. An unexplained indigestion which results in loss of appetite expecially for meats is often the first sign of cancer of the stomach or intestines. Persistent hoarseness or difficulty in swallowing for a period of ten days or more without any obvious explanation may be a sign of cancer of the throat.

Pain is a definite sign of cancer in bone or nervous tissue. Pain also may occur in a cancer of the tongue, but since pain is a late symptom it should not be waited for as cancer is then well advanced in development.

Approaches

1. Show stereoptican slides or kodachrome slides on cancer of photographs from current magazines such as *Life*, *Fortune*, *Time*.
2. Have exhibits of cancerous tissue growths in biology classes for individual study by small groups. These should include samples from each of the body parts mentioned above and be open to parents as well as to students.
3. Posters, pictures, statistics, slide pictures, drawings, pamphlets, etc., should be included in the above display.
4. Field trip to see cancer exhibits of specimens of tumors in body tissues and models, showing lesions in various sections, also plant tissues showing cancerous growths—2nd floor Old Memorial Hospital, 106th St. & Central Park West (or other Hospitals).
5. Show motion picture "Choose to Live," 16 mm. 2 reels, sound film—18 minutes. A human interest story, recording facts about cancer, cancer control, research, treatment and public instruction.

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Prevalence

According to reported death rates cancer seems to be increasing. This may be due to improved methods of diagnosis or to the fact that a greater percentage of the population now lives to reach the so-called cancer age. The cancer death rate, the number of deaths per 100,000 population has increased from 64 per 100,000 in 1900 to 140 per 100,000 in 1946. In comparison with other diseases as a cause of death it occupies second place, as seen from the following table compiled in United States in 1944.

Diseases of the Circulatory System	450,563
Cancer and Other Tumors	177,600
Diseases of the Nervous System	140,501
Violent or Accidental Deaths	115,204
Diseases of the Genito-Urinary System	107,289

No age is free from cancer. Certain forms of cancer are most often found in young children. The age distribution of cancer deaths in United States in 1945 is shown following:

Age	
Under 15	1,290
15–29	2,543
30–44	14,299
45–59	49,239
60 over	109,998

Approaches

1. Compare the death rate from cancer in Denmark in 1940 with that in United States in 1945.
2. Collect statistics of the cancer death rate and prevalence in New York State and compare with other states in United States.

3. Compare the death rate from cancer in the Eastern States with that in the Western and Middle Western States.

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Treatment of Cancer

The prevailing misconception that cancer is a hopeless and incurable disease is not entirely correct. Cancer, if taken in time, is curable and can be removed. Surgery, radium, and X-rays, in the hands of a skilled physician, are today the only recognized effective treatments for cancer. In justice to the patient, each case must be treated as an individual problem. Sometimes a combination of these three methods is necessary for effective treatment. Many lives are sacrificed by trifling home remedies and other unscientific methods of treatment. There are no "quack" or easy remedies. There are hundreds of thousands of such fake treatments and the American public pays dearly for their use in cash, in suffering, and in sorrow. There are no records of reliable and helpful serums, injections or treatments by diet.

Radium is the most important of the radio-active elements of the earth. Its activity depends upon the emission of penetrating rays during its slow disintegration. These radiations are of three kinds, called Alpha, Beta and Gamma rays. For therapeutic purposes radiation is obtained from the element itself and from the radium emanation (radon), the gas which results from the continuous disintegration of the element. Radium is applied in needles, small glass tubes, and as a large pack. Radon is applied in the form of small gold tubes or seeds called implants.

The four principal methods of applying radium and radon in cancer are as follows:

(1) External application (deep therapy). A block (pack, bomb) of radium, consisting of from one to four grams, heavily screened with lead, is applied at a distance from the skin for the irradiation of internal tumors.

(2) Surface or contact application. Tubes or plaques of radium, or radon, with or without filters, are placed in immediate contact with an external tumor.

(3) Cavity application. Tubes of radium or radon are placed within the body cavities, as in the uterus.

(4) Interstitial application. Needles containing radium or radon, or implants containing radon, are placed in the tumor or about it. The needles in such cases are removed, but the small implants are left in the tissues permanently without any harm.

X-rays are produced by the passage of a high voltage electric current through a glass-walled vacuum tube. The X-ray differs from the Gamma rays in its wave length, but has the same effect upon tumors and normal tissues. The two types of treatment that are most often used are superficial therapy, in which low voltage, soft, less penetrating rays are used; and deep therapy in which large doses of high voltage, hard penetrating rays are created and delivered to the internal areas of the body. These two types of X-ray treatments are used in conjunction with surgery and the Gamma ray of radium.

Another method of treating cancer is by electro-surgery. It is most commonly done in the ways listed below:

(1) The actual cautery (electrocautery). Here the applicator itself is heated and cauterizes or burns the tissues.

(2) The endotherm knife (radio knife). Here is a high-frequency current from a vacuum tube which produces short sparks in a fine wire loop. The tissues are rapidly divided without pressure and with slight hemorrhage, and primary union occurs.

(3) Fulguration. Here is a high-frequency caustic spark producing superficial destructive action upon the tissues. It is used to destroy growths upon the skin and mucous membrane, especially in the bladder.

(4) Electric desiccation. Here a high-frequency, high-voltage, low amperage current is employed with an ordinary steel sewing needle as an electrode. It is used to remove superficial cancerous growths. The tissues are dried but not carbonized. The desiccated tissue is removed by a curette.

Approaches

1. Show motion picture "Conquering Cancer"—March of Time film, 16 mm. 1 reel, 7 minutes, sound film. Covers leading personalities in fight against cancer, in research, therapy, and public instruction. It warns against quacks and emphasizes the need for wider public knowledge of the facts about cancer.
2. Arrange field trip to a hospital in your neighborhood to see what is being done in cancer control.
3. Have speaker from local chapter of American Society for Control of Cancer on the latest developments in the treatment of cancer.

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The Public and the Cancer Problem

Up until the present time the fight against cancer has been carried on largely by the medical profession, research foundations, and the American Society for the Control of Cancer. Recently it has been introduced into some of the more progressive schools as a part of functional biology.

But until the laymen, the parents of the boys and girls studying this unit, are willing to assist—not much more can be done. It is through this method that we hope you will educate yourself and your parents, remembering that cancers arise from long-continued constant irritation and are preventable if taken in time. Here are a few points about which to be alert: (1) Abnormal bleeding from body cavities is a real danger sign. It must be investigated at once. (2) A persistent sore in the mouth or tongue must have prompt medical attention. These sores may be caused by improper dental or oral hygiene. (3) Indigestion is often due to stomach ulcers or gall bladder disease, which if not corrected in time may result in cancer. An X-ray examination may prevent this. (4) Biopsy, a microscopic examination of an abnormal lump in the breast or elsewhere, may show whether or not a tissue is cancerous. This method has increased the cure of cancer by a high percentage.

Observation of these suggestions not only may prevent cancers, but also may aid physicians in locating unsuspected cancerous growths. Physicians are only too anxious to cooperate and a regular physical examination will aid in that cooperation.

From an economic standpoint it is important that the very first sign of cancer be promptly investigated, for the cure which is possible at that time means a saving of earning power for the individual and of man power production for the nation; it prevents broken homes, allays fears, and eliminates the most costly treatment which is necessary if it is neglected.

Finally, the reduction of cancer death rests squarely upon the children of today who will know how to approach the "cancer age" with the forces of fear, ignorance and quackery dispelled by knowledge. Thus, a growing army of people, equipped with this knowledge and inspired with courage is the best insurance that we can have against the future cancer problem.

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NOTE ON THE RULE OF SIGNS

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A perennial subject for discussion among teachers of mathematics is the troublesome one of explaining to high school pupils why the product of two negative numbers is positive. Conclusions range all the way from asserting that "mathematicians have agreed that it should be so" to discussions presumed to prove that it must be so. Few teachers are content to attribute so important a rule to an agreement by mathematicians, and few concede the logic of the proofs that it must be so.

In a recent article,* Professor Howard F. Fehr gave an excellent treatment of the logic of the rule. It is doubtful whether more can be said on this phase of the problem at the present time. In *Problems in Teaching Secondary School Mathematics* Professor Ernest R. Breslich has discussed a number of ways by which the rule can be made to seem reasonable to learners. Other illustrations can easily be added to Breslich's list. Any of these should make high school pupils ready to accept the rule as rational.

It seems to the present writer that rationalization is all that the high school teacher should be concerned with in her teaching. As a student of mathematics she may add an interest in logic and above all in consistency. All the conventions, illustrations, and rationaliza-

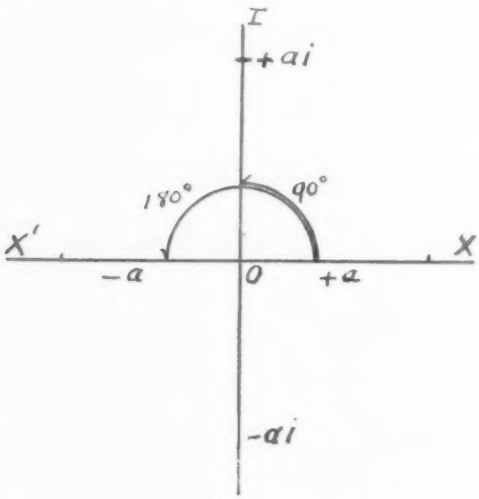

FIG. 1

* *Operations in the Systems of Positive and Negative Numbers and Zero.* Howard F. Fehr, *Mathematics Teacher*, April, 1949.

tions of mathematics must agree wherever they make contact in any common field.

I wish to add one more illustration or rationalization of the product rule for signed numbers. It is an extension to three dimensions of Wessel's two dimensional geometric illustration of complex numbers.

You will recall that Wessel greatly clarified complex numbers by assuming that a line segment rotated 90° in a positive direction has its magnitude multiplied by i. Thus a segment a rotated through $-90°$ gives $+ai$, and rotated through $-180°$ gives $ai^2 = -a$. The latter value is consistent with the convention of regarding a length a to the left of the origin as $-a$.

Now, suppose we consider a line YY' perpendicular to Wessel's plane at O. This adds to the system two planes, the XY-plane of real numbers and the IY-plane of complex numbers. Consider a rectangle

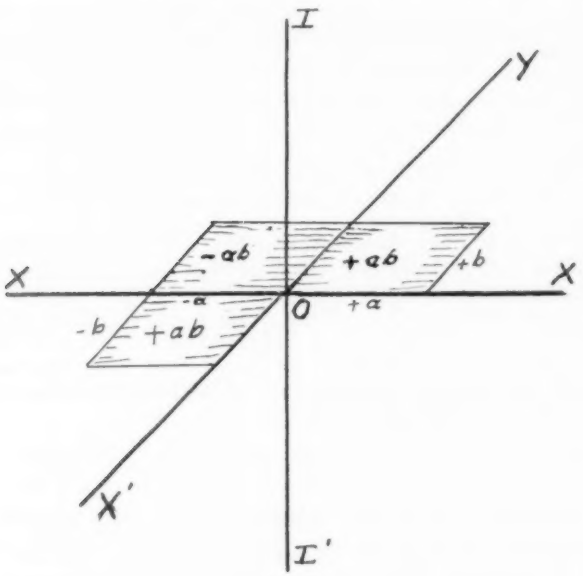

FIG. 2

in the first quadrant of the XY-plane and let its dimensions be a and b. Its area is $+ab$. Let this rectangle be rotated negatively about the Y-axis until it lies in the IY-plane. Extending Wessel's convention, we may regard the area of the rectangle as now being abi. Let the rectangle be rotated through another negative angle of 90° until it lies in the second quadrant of the XY-plane. Extension of Wessel's convention would indicate that the area ab should be multiplied by i^2 giving $-ab$. This agrees with the conclusion reached by all accepted illustrations for the product of $-a$ times $+b$.

Now, rotate the rectangle through 180° about the X-axis. It will lie in the third quadrant of the XY-plane and both a and b are negative. By Wessel's convention the area $-ab$ is multiplied once more by i^2. This gives $-i^2ab = +ab$.

Thus, the extension to three dimensions of Wessel's two-dimensional convention leads to $+ab$ as the product of $-a$ times $-b$.

The only conclusion that can be urged from this development is that its results are consistent with those reached by other illustrations. We have proved nothing, but the fact that we reach a conclusion consistent with that reached from other considerations gives an added feeling of confidence in the old rule.

NEW FILMS FOR THE GRADES

Care of the Skin, a film designed to make children want to be clean, has just been released by Encyclopaedia Britannica Films.

The new one-reel black and white 16 mm. motion picture demonstrates cleanliness techniques by showing three youngsters as they carry out their bedtime preparations. Most children will easily identify themselves with the Virginia, Billy and Fred of the film and learn, graphically, but indirectly, *why* cleanliness is so important, Dr. V. C. Arnspiger, executive vice-president of EBFilms, said.

Animated drawings describing the structure of the skin are accompanied by a narration in simple, non-technical language to supplement the story. Common skin diseases are also illustrated.

Save Those Teeth is a new 16 mm. sound film just released by Encyclopaedia Britannica Films, which has as its theme practical first-hand demonstrations of several aspects of tooth care.

Since ninety per cent of all American children, six years or older, are said to have decayed teeth and it has been estimated that it would take three hundred thousand dentists to repair all of the teeth that now need attention, an understanding of simple preventive measures is of importance in any dental health education program for children or adults.

ALUMINUM SCRAP YIELDS PURE ALUMINUM

Aluminum scrap containing silicon and iron can be made to yield its aluminum by a new U. S. Bureau of Mines process which involves dissolving.

The aluminum is dissolved in molten zinc and the zinc is then distilled from the aluminum. Both laboratory and pilot-plant distillation tests have been made.

To obtain pure aluminum by direct reduction of clay or siliceous bauxite in an electric furnace requires a practical, inexpensive method for refining aluminum-silicon alloy.

Most pure aluminum today is produced commercially by an electrolytic process, not by direct smelting of siliceous aluminum ores.

Containing detailed information on tests made, the report covers the production of crude aluminum by carbothermic reduction, multi-stage reduction, and data on the boiling points of zinc-aluminum alloys. Copies may be obtained free from the Bureau of Mines, Pittsburgh, Pa.

The title is "Recovery of Aluminum from Crude Aluminum-Silicon Alloy by Extraction with Molten Zinc."

A PROPOSAL FOR A MODERN PROGRAM IN MATHEMATICAL EDUCATION IN THE SECONDARY SCHOOLS

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The history of the development of mathematics as a subject of study in the American secondary schools is interesting, highly revealing of the growth and effect of educational philosophy, and especially reflective of the impact of social and economic forces. The history is not written in one place, but must be garnered from historical writings, research, and publications by the Learned Societies. The writing of a complete history of mathematical education in the secondary schools of the United States of America remains as a task, a very necessary task, still to be accomplished.

Since 1900, the secondary school has thought primarily in terms of college preparation and business preparation, with the later addition of vocational education. Thus we had an established sequence of college preparatory algebra, geometry, and trigonometry, and also a course in business arithmetic. In general this pattern still prevails in our schools, although there has been an entire change in population, purpose, and needs in a high school program. The time has come when we must develop an altogether new program for the new high school; we cannot patch up, dilute, or adjust the college preparatory course of the past to meet the needs of all high school pupils of the future.

During the last few years at various places there has been stressed the need for revising the mathematical offerings of our schools in accordance with the demands of modern social, economic, political, cultural, and scientific endeavors of our society. Some of these purposes of the future high school were stated so explicitly by Galen Jones,[1] Director of the Division of Secondary Education of the United States Office of Education, that I shall use them as a basis of my discussion.

First: "The high school of the future will enroll all normal adolescents and serve them properly." The words "normal" and "all" are significant. By normal is meant those pupils from ages 12 to 18 who do not have to be committed to institutions. It means those pupils whose I. Q.'s range from 65 (or even lower) on up, or with mental ages from 8 years to that of the superior adult. By all is meant 100% of the youth of these ages. What a contrast to the past! In 1900 only 12% of the youth of these ages were in the secondary school, and they

[1] Teachers College Record, April, 1949, *The High School of the Future.*

were usually the high intelligence group. In 1920 this per cent had risen to about 40. In 1940, it was about 70%, the highest per cent ever reached. In 1960 we must look for all of the youth of high school age. What program of mathematical education shall we have to serve them?

In 1934, of 1000 fifth grade pupils only 792 entered the ninth grade, and only 462 graduated from high school. Thus by the senior year less than 50% of the pupils of high school age have remained in school. Now—why? Up to the 1920's there were many economic barriers, and other social reasons for the drop-outs. But in the 1930's and 1940's there is a different and outstanding reason for the exodus: The high school has nothing of value or of interest to offer these pupils. Failing year after year in classes in abstract work beyond their capabilities is not developing character or desirable attitudes and habits in pupils. In fact it is the very opposite of training for life in a free society.

This fact was recognized far earlier than 1930 by educators who were deeply concerned, and who, through various committees, published new aims, objectives, and revised curriculums, to meet what they assumed was the purpose of the high school. Most committees on mathematical education from 1900 to 1916 advocated a four year course in the senior high school, of a rigorous type, to be taken by all pupils, if for no other purpose than for its mental value. In revisions made since that time, provisions were made to make the subject elective for some pupils and also to simplify the existing courses of study, but always to save the traditional college preparatory type of instruction. Protests were made but very little was done about the large number of failures, except to excuse pupils from continuing the study of the mathematics offered.

Other reforms effecting mathematical study were proposed, for example, the cardinal principles, which were supposed to change radically our whole program. This set of principles allowed little place for mathematics instruction and there began a general reaction against any compulsory study of mathematics, culminating in a situation very prevalent throughout the country, which permits a pupil to graduate from a four year high school without having a single day's study of mathematics. However, the seven cardinal principles did not make too much impression on the established order, for today there are few people who can state all seven principles.

Other innovations were made to keep every one in school. Supervised study, no home assignments, the contract plan, universal promotion, all promised a better day, but still nothing happened in mathematics except further simplification of college preparatory mathematics, lowering of standards for promotion, and the addition of substitute subjects. Manual arts, home economics, music and art

were offered in place of algebra, Latin, physics, and other academic studies for the general student, but it was not long before the teachers in these new subjects demanded almost the same superior mental ability as was required for success in the academic subjects. Again the below average child found nothing of value in the high school program; nothing adapted to his particular interest, need, and level of ability. For these people, concrete practical skills and facts, proper attitudes, the recognition of the value of elementary forms of mathematics, and careful development of good conduct are more important than mechanical manipulation of meaningless abstractions. The only real modification came through a series of studies from 1920 to 1940 on the very lowest mental abilities culminating in an unscientific, heterogeneous set of texts on 9th grade general mathematics. This is not the answer to the problem of mass education.

If all eligible pupils attend our high schools, then at least 70% of them need a program of education that exists in very few schools today, a program in which they can find success, interest, absorption, and definite values for subsequent life. To the extent that the schools will provide this, to that extent they will be successful. Why do parents so frequently insist that their children take college preparatory mathematics? Because in the past this was the only criterion of success. A school was rated good if it succeeded in getting its graduates into recognized colleges. Thus a boy is good if he can pass college preparatory mathematics. To all parents their children are always good. If a boy is deprived of a chance to study college preparatory mathematics he is deprived of an opportunity to show he is good. To combat this fallacious idea of success, we must immediately abolish success in college preparatory mathematics as the sole criterion of the success of a high school program. The high school of tomorrow will not dare to brag only about the number of its graduates who are admitted to college, but it may well tell with pride, how many of all the eligible youth of the community it has graduated adequately equipped to enter the democratic life of that community. For this latter purpose we need to construct an entire new program of mathematical education in the high school.

Who should do this? All the teachers and all the various social organizations related to education working together. It has been frequently said that only a group of experts can be trusted to write a curriculum or a course of study, or a text book. However true this may have been in the past, it will cease to be true in the future as the democratic process more and more forces itself into action. The modern teacher cannot teach a superimposed course, except in a methodical, static, lifeless way. His own course he can make adaptive to, dynamic in, and living through the minds of his pupils. Further,

this community of labor in the production of a curriculum is necessary to achieve both the *second* purpose,

"The high school of the future will develop the common learnings program that is required for the unity of American life and culture." and also the *third* purpose,

"The development of differences so highly prized in a free society will be a central concern of the secondary school of the future."

These purposes can be rephrased in the statements that we recognize no superior group of individuals, but that we do recognize superior people in all groups. The superior persons, so far as mathematical education is concerned, must be given every opportunity to develop their talents so that they can make contributions for a better life for all the people. The provisions for these superior abilities is a necessity for progress, as well as a recognition of the essential dignity of each individual pupil. But no matter how differently we may live as individuals in different spheres of life, we recognize a wide base of common elements of learning for all people in all spheres and this base can become the solidifying element of instruction, a common learnings program. The solidifying element may be in part the content of mathematics which all men need in their daily use in the home, business, and social life. But it is more than that. It is those aspects of number and of space which are necessary for proper communication of thought, in the understanding of the world about us, in talking about world relations that affect the life of every one of us. Debates upon world banking and financial proposals that cannot in some form be made quantitatively intelligible to the average citizen, cannot conduce to preserving a real democratic society.

In the minimum essentials list in the second report of the Post-War Commission we have a start on some of the solidifying elements in our every day life. This list should be revised in terms of peace-time as well as war-time necessities, and this will entail an increase in the essentials. If increasing minimum essentials can lead us to a better life, it must be done, even if it is so simple a task as mastering the practical interpretation of tables of compound interest and of insurance premiums.

The differential aspect of learning in mathematics may be that mathematics which the individual needs for his selected vocation or profession. But it is more than this. It is an adaptation of the degree of abstraction, of generality, and of systematized knowledge in the field of mathematics to the individual differences in ability to master this type of work. The program must provide the opportunity for all children to act, to create, to discover, to learn according to their stage of development. It also means that we must direct this learning so that pupils will work to capacity and take responsibility for their

learning, and so that that they will preserve and organize the good, and discard the unnecessary and bad activities.

To accomplish this type of program is the *fourth* objective, "The secondary schools of the future will pursue a thorough program of pupil study and provide effective guidance service." This calls for a more highly trained and superior type of teacher of mathematics, a teacher who also possesses creative intelligence and exerts responsible action. As mentioned previously, until the teacher takes an active part in creating the educational program, we shall not achieve a democratic process. In the past and even today the teacher is not encouraged to take part in creative processes of the educational program. In New York the Regents dictate the program, in other states similarly imposed courses are required study; the teacher must accept it and merely teach. In other cases the superintendent or principal expects the teacher to teach the book and not stir up community trouble that may make life more risky for the administration. Very rarely is a department of teachers urged to study and create its own program. But teachers will never become professional in the true sense, until they take this all absorbing interest in the creation and extension of their work.

Guidance does not mean telling a student he is or is not able to take a course in mathematics, or that unless he takes certain courses he cannot proceed to certain advanced study. It consists more of telling the student the type of mathematical study he is ready to undertake and then providing such study for him. How can a teacher give such guidance unless he is fully aware of the aims and content of the whole field of secondary mathematics and the way in which his instruction can be of value to the pupils? The whole significance of all this is that a brand new curriculum in mathematics must be created for more than half of our high school population and the teachers all over the United States must develop this material. What will decide the nature of this course? The answer is in the *fifth* purpose of the modern school:

"The secondary school of the future will evaluate its effectiveness in terms of how well it has developed the citizens of and for a free society."

The aims of citizens in a free society have been stated in many different forms. According to the Harvard Report on General Education in a Free Society, the primary abilities to be developed by every individual are

(1) To think effectively
(2) To communicate thought
(3) To make relevant judgments
(4) To discriminate among values

If we accept these aims, it is the responsibility of the future high

school mathematics teacher to develop these abilities insofar as they affect all quantitative thinking, that is, thinking in terms of number and of space. We must seek to determine the extent to which these abilities are capable of development in individuals at the various levels of mental ability, and then proceed to their attainment.

With this background of philosophy and purpose, I would like to initiate a proposal for a modern program in high school mathematics. In the six years of elementary school we teach the common learnings, the solidifying elements of our society. All pupils regardless of ability mix together and study the same material, albeit, without achieving the same results. Each year the divergence of ability grows wider and wider. The junior high school, school years 7, 8 and 9, preserves and continues these common learnings, but also provides an opportunity for individual differences and interests to emerge and bloom. This calls for an ever-widening program of mathematical instruction, until we reach the 9th year, when, in my judgment, it becomes necessary to create at least two distinct types of mathematical education. This can best be shown by the study of these figures.

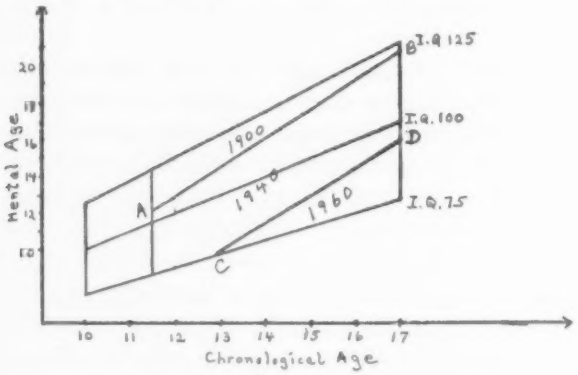

FIG. 1

In Figure 1, the mental age is plotted against the chronological age. Age 12 corresponds to the 7th school year. The area above line *AB* indicates the part of the population of youth from ages 12 to 17 that was in school in 1900. In general this population consisted of the highest intelligence group and explains the type of high school program administered at this time. The area above the line *CD* shows the percent of the eligible population that was in high school in 1940. By 1960 we can expect that most of the population below line *CD* will also be in high school. If universal promotion, now so prevalent in the elementary school, is accepted in the high school, as it must, when the high school adapts itself to serving all the youth, it will bring many new problems.

In Figure 2, the chronological age has been converted into the equivalent school grade. Line *A* shows that the lowest ability group in grade 8, is at that time ready to do average 5th grade work in mathematics. Line *B* shows that the lowest ability group entering grade 12 is now ready to do the average ability work of beginning 8th grade or the type of work that superior 5th grade pupils can do. This is startling and challenging when we realize that three years later these pupils will be voting citizens in our democracy.

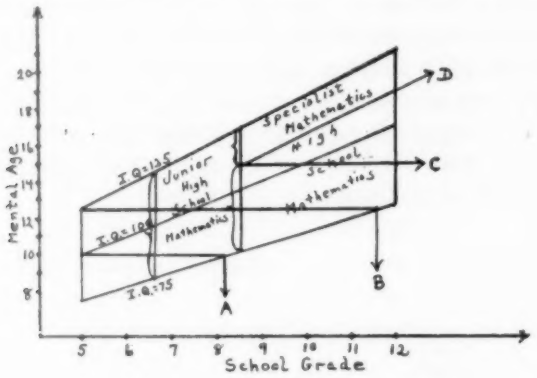

FIG. 2

Line *C* is indicative of first year algebra ability. It shows that the average high school pupil will not be ready for such study until the middle of the tenth year and that many high school pupils will not attain this ability even by the end of the twelfth school year. Line *D* is drawn to indicate the proposed division of study between the *regular* high school population and the future specialist.

Grade 9 is shown as the starting point of adapting pupils to a differentiated program which they will pursue in the senior high school. The high school program for the great group should be a sequential course from the 7th to the 12th grade preserving and extending the common learnings and stressing that type of mathematics that contributes to the needs of citizens in a free society. This course must be so flexible and broad in nature to adapt itself to all levels of ability, even to the extent of teaching the average 7th grade concepts to the least able pupils in the eleventh year. The study of mathematics should be available to all pupils who desire to study it. Besides this sequence of six years of high school mathematics, we must develop those pupils of superior ability by special courses in the abstract mathematical theory. These courses could well be reserved as specialist mathematics for the 10% or 15% of the population which consists of superior academic students, the only group that was privileged to stay in school in 1900. The material offered must be on a higher intel-

lectual level than most of the present college preparatory offerings, and not necessarily the same type of algebra and geometry. These courses should adapt themselves more to the modern mathematical spirit, and away from traditional Euclidean and "put and take" algebraic methods. It should be carefully recognized that while these courses may act as passports to specialized collegiate instruction, high school mathematics taken by the great middle group may also be regarded as preparation for certain types of college and post-high school education. College entrance is not to depend entirely on taking highly specialized mathematics courses. The ideal is a high school program in mathematics adapted to the capacity, interest, and needs of all pupils as future members of our society. The content and administration of this program is a problem demanding immediate solution. The solution is a task for all the teachers, students and administrators of secondary school mathematics programs.

THE LIVING FOREST

The Living Forest Series, released by Encyclopaedia Britannica Films, is a group of three 16 mm. one-reel films in full color which takes for its central theme one of the most important aspects of conservation—the intelligent use and scientific renewal of America's forest resources.

Sequels to the four motion pictures released in 1948 as *The Living Earth* Series, the three films are entitled *The Forest Grows*, *The Forest Produces*, and *Forest Conservation*. They were produced by the Conservation Foundation in association with the New York Zoological Society of which Fairfield Osborn, author of *This Plundered Planet* is president. The series points out that "taking" more from the forest than is "given back" will mean national calamity, for the forest is a vital part of the nation's economy.

The films show that forests are the source of our timber supply, and the background of the lumber industry which furnishes over three million jobs. The Forests' roles as the guardians of life-giving topsoil and water supply are demonstrated in the films and the color photography shows them as the natural homes of countless species of wild life and places of beauty for man's recreation and enjoyment.

SPEED-ACCELERATION

Speed is the rate of travel of an object. It is expressed in miles per hour or feet per second.

Velocity is not just a hard way of saying speed; it means speed in a given direction. Velocity in one direction is not at all the same as velocity in another direction even though the speed may be the same.

Acceleration is the rate of increase in velocity. A car that has a quick pick-up accelerates well. Acceleration is usually expressed in feet per second per second. The repetition of "per second" is not a misprint because acceleration means change in velocity. It is the increase in speed (feet per second) that occurs in each second.

A COMPARISON BETWEEN THE SCORES OBTAINED ON A SCIENCE ACHIEVEMENT TEST BY STUDENT TEACHERS IN SCIENCE AND BY HIGH-SCHOOL PUPILS

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THE PROBLEM

The purpose of this investigation was to compare the subject-matter backgrounds of student teachers who were completing their training as teachers of high-school science with those of pupils in classes of high-school science.

TECHNIQUES EMPLOYED

An earlier investigation[1] reported the procedure by which the subject-matter backgrounds of the student teachers in science were measured. A similar procedure was used in this study for evaluating the subject-matter backgrounds of the pupils in high-school science. In essence, a science achievement test covering four areas of science was administered to the student teachers in science and to the pupils in high-school science. As was stated in the report of the preceding study the test items were obtained from the Regents Examinations of the University of the State of New York in the areas of earth science, biology, physics and chemistry. The test consisted of two parts. The first part contained four sub-tests, each of twenty-five items of the factual or short-answer type, in each of the areas of earth science, biology, physics and chemistry. The sub-tests in all of these areas were constructed so as to be of equivalent difficulty. The second part contained five items in each of these same areas, but these items required the application of a scientific principle and were of the essay type. The sub-tests in Part II were constructed so as to be of equivalent difficulty also.

It was decided to administer the tests to high-school pupils in the same states as those in which the student teachers had been trained. The high-schools selected were those having enrollments of below two hundred and fifty, since the newly-graduated teachers seemed likely to be employed first in such schools. Five schools agreed to participate in this study.

The tests were then administered to all of the pupils in these high schools who were "majors in science." A "major in science" was con-

[1] Mallinson, George Greisen, "An Investigation of the Subject-Matter Backgrounds of Student Teachers in Science." SCHOOL SCIENCE AND MATHEMATICS, XLIX (April 1949), 265–272.

sidered to be a pupil who had taken a course in ninth-grade general science and who also at the time of the experiment was taking either physics or chemistry.

The tests were administered during the months of April and May of 1949 to the high-school pupils already designated, and were returned to the writer for scoring. The system for grading and for scoring the examinations was the same as that used for grading and scoring the test papers of the student teachers in the previous study. In order to reduce the possibility that a low score on the final section of Part I or Part II might be caused by the failure of the pupils to complete that section, the tests were discarded of those pupils who had failed to respond to the last four items of Part I, or the last two items of Part II.

After the tests had been received, the groups of pupils were further reduced by including only those who had taken general science in the ninth grade and who had taken two of the three "high-school sciences," namely, biology, physics and chemistry. Eighty-three usable tests were thus obtained.

The results were first tabulated on the basis of the mean scores obtained by the pupils in each high school, and then for all of the schools combined. For obvious reasons the high schools are designated by symbols. However, High School *A* and College *A* (See previous investigation) are in the same state.[2] High School *B* is in the same state as College *B*. The locations of the other schools are similar except High School *E* and Colleges *E* AND *F* are located in the same state.

These scores were then compared with the corresponding scores of the student teachers of the preceding study. Table 1 summarizes the results and includes also the mean scores obtained in the previous study by the student teachers taken as a single group.

TABLE 1. MEAN SCORES ON SHORT-ANSWER, ESSAY TYPE AND COMPOSITE TESTS

High School	Short-Answer				Essay Type				Composite			
	Earth Sci.	Biol.	Phys.	Chem.	Earth Sci.	Biol.	Phys.	Chem.	Earth Sci.	Biol.	Phys.	Chem.
A	11.36	10.36	16.27	9.64	16.27	13.73	16.91	7.73	27.64	24.09	33.18	17.36
B	9.33	7.73	10.00	12.83	15.53	14.73	16.07	11.60	24.86	22.46	26.06	24.43
C	10.00	9.67	8.22	8.33	11.78	15.67	14.33	9.89	21.78	25.33	22.56	18.22
D	9.00	12.18	7.73	12.64	14.27	13.82	11.27	11.18	23.27	26.00	19.00	23.82
E	10.73	8.45	10.00	12.00	15.00	15.09	13.64	10.59	25.73	23.55	23.64	22.59
All High-School Pupils	10.00	9.07	10.34	11.68	14.79	14.67	14.71	10.58	24.92	23.44	25.05	22.25
All Student Teachers	11.49	14.00	11.40	9.62	11.32	13.58	11.24	4.96	22.81	27.58	22.64	14.58

[2] Although outside the scope of this study, it would be possible to compare state by state the scores obtained by the student teachers and by the high-school pupils.

From the data from Table 1, the "*t*" test of significance[3] was applied to determine the significances of the differences between the mean scores obtained on the various tests by the student teachers and by the high-school pupils. The "*t*'s" were computed for the differences between the mean scores obtained by the student teachers taken as a group and the high-school pupils taken as a group on the short-answer, on the essay type and on the composite tests for each of the four fields of science. For example, "*t*" was computed for the difference between 10.00 and 11.49, which are the scores obtained by the high-school pupils and student teachers respectively on the short-answer test for earth science. A similar computation was made between the mean scores 14.79 and 11.32 which were obtained by these two groups on the essay type test for earth science. Table 2 summarizes the results of these computations.

TABLE 2. COMPARISONS BETWEEN MEAN SCORES OBTAINED BY STUDENT TEACHERS AND HIGH-SCHOOL PUPILS ON THE BASIS OF SUBJECT-MATTER AREAS

Test	Mean Difference	S.E. Mean Difference	"*t*"	Probability Level	Interpretation
Short-answer					
Earth Science	1.49	.579	2.573	$.05 < P > .01$	Signif. Diff.
Biology	4.93	.727	6.781	$P < .01$	Signif. Diff.
Physics	1.06	.861	1.231	$P > .05$	No Signif. Diff.
Chemistry	2.06*	.795	2.591	$.05 < P > .01$	Signif. Diff.
Essay Type					
Earth Science	3.47*	1.038	3.343	$P < .01$	Signif. Diff.
Biology	1.09*	1.035	1.053	$P > .05$	No Signif. Diff.
Physics	3.47*	1.180	2.941	$P < .01$	Signif. Diff.
Chemistry	5.62*	.876	6.415	$P < .01$	Signif. Diff.
Composite					
Earth Science	2.11*	1.401	1.506	$P > .05$	No Signif. Diff.
Biology	4.14	1.643	2.519	$.05 < P > .01$	Signif. Diff.
Physics	2.41*	1.948	1.232	$P > .05$	No Signif. Diff.
Chemistry	7.67*	1.611	4.761	$P < .01$	Signif. Diff.

* These differences are in favor of the high-school pupils.

The results obtained by the high-school pupils on these tests were retabulated for each school and as a total group in the following way: The scores made by each pupil on the short-answer tests for each of the four fields of science were arranged in ascending order. Thus, when the mean scores for each school were computed, the individual scores may have been from any one of the four fields of science.

[3] Guilford, Joy P., *Psychometric Methods*. New York: McGraw-Hill Book Co., 1936. Pp. 61–62.

Therefore, the lowest mean score for each school was computed from the sum of the lowest scores of all of the pupils in that school, without regard for the field of science in which the scores were made. The second lowest mean score was computed from the sum of the second lowest scores of all of the pupils; and so on for each of the remaining scores on the short-answer examinations. A similar computation was made by using the four scores received by each pupil for the essay type questions, and for the composite tests. Finally, all of the high-school pupils were considered as one group and computations were made on the group basis in the same manner. Table 3 lists the information just cited and includes also the similar scores obtained in the previous study by the student teachers taken as a single group.

TABLE 3. MEAN SCORES OBTAINED ON THE BASIS OF ASCENDING ORDER OF SCORES FROM FOUR FIELDS OF SCIENCE

High School	Short-answer				Essay Type				Composite			
A	8.09	10.55	12.73	16.27	7.64	13.00	15.73	18.27	16.82	24.18	27.82	33.45
B	5.93	8.70	10.53	14.73	8.50	13.27	16.23	19.93	16.23	22.53	26.30	32.77
C	5.00	8.78	10.90	12.33	8.56	11.44	13.22	18.44	14.67	20.33	24.22	28.67
D	7.00	8.64	11.73	14.14	8.45	10.64	13.91	17.55	17.27	20.91	25.55	28.36
E	5.91	9.86	11.55	13.86	8.45	12.50	15.32	18.05	16.41	22.50	26.18	30.64
All High-School Pupils	6.25	9.27	11.20	14.36	8.37	12.48	15.28	18.73	16.33	22.23	26.15	31.27
All Student Teachers	7.57	10.38	12.63	15.94	3.89	8.81	12.34	16.06	12.48	19.76	24.61	30.79

By using the data from Table 3, the "*t*" test of significance was applied to determine the significances of the differences between the mean scores obtained by the student teachers and by the high-school pupils on the various test categories. For example, "*t*" was computed between 6.25 and 7.57, the lowest mean scores obtained by the high-school pupils and student teachers respectively on the short-answer tests. "*t*" was also computed between 9.27 and 10.38, the second lowest mean scores obtained by these groups on the short-answer tests. Similar computations were made between the mean scores obtained by these groups on the other test categories. Table 4 summarizes the results of these computations.

SUMMARY OF FINDINGS

Insofar as the results of this study may be valid, the following conclusions seem defensible: From the data in Table 2, it may be seen that eight of the twelve differences in mean scores of the two groups are statistically significant. The student teachers scored significantly higher than did the high-school pupils on the short-answer tests in earth science and biology, and on the composite test score in biology. Also, they scored higher than did the high-school pupils on the short-

answer test in physics; the difference was not however statistically significant.

The high-school pupils scored significantly higher than did the student teachers on the short-answer test in chemistry, on the essay type tests in earth science, physics and chemistry, and on the composite test in chemistry. Also they scored higher than did the student teachers on the essay type questions in biology, and on the composite tests in earth science and physics, although the differences were not statistically significant.

TABLE 4. COMPARISONS BETWEEN MEAN SCORES OBTAINED BY STUDENT TEACHERS AND HIGH-SCHOOL PUPILS ON THE BASIS OF ASCENDING ORDER OF SCORES

Test	Mean Difference	S.E. Mean Difference	"t"	Probability Level	Interpretation
Short-answer					
Lowest score	1.32	.666	1.982	$P > .05$	No Signif. Diff.
Second lowest	1.11	.629	1.765	$P > .05$	No Signif. Diff.
Second highest	1.43	.631	2.268	$.05 < P > .01$	Signif. Diff.
Highest	1.58	.669	2.361	$.05 < P > .01$	Signif. Diff.
Essay Type					
Lowest score	4.48*	.644	6.957	$P < .01$	Signif. Diff.
Second lowest	3.67*	.940	3.904	$P < .01$	Signif. Diff.
Second highest	2.94*	.942	3.121	$P < .01$	Signif. Diff.
Highest	2.67*	.917	2.912	$P < .01$	Signif. Diff.
Composite					
Lowest score	3.85*	1.299	2.959	$P < .01$	Signif. Diff.
Second lowest	2.47*	1.414	1.747	$P > .05$	No Signif. Diff.
Second highest	1.54*	1.446	1.065	$P > .05$	No Signif. Diff.
Highest	.47*	1.499	.313	$P > .05$	No Signif. Diff.

* These differences are in favor of the high-school pupils.

The data from Table 4 provides evidence that is similar to that provided by Table 2. There are many differences between the mean scores obtained by the student teachers and those made by the high-school pupils when the scores are considered in ascending order of range. When considered in this way the student teachers scored significantly higher than did the high-school pupils on the second highest and the highest of the mean scores on the short-answer questions. They also scored higher than the high-school pupils on the lowest and second lowest mean scores on the short-answer questions but the differences were not statistically significant.

However, the high-school pupils scored significantly higher than the student teachers on the lowest, second lowest, second highest and highest mean scores as computed for the essay type questions.

The high-school pupils also scored significantly higher than the student teachers on the lowest composite mean score. They also scored higher on all of the other composite mean scores than did the student teachers but the differences were not statistically significant.

It may be stated defensibly, therefore, that high-school pupils who major in science perform better generally on science achievement tests designed for high-school pupils than do student teachers. The superiority is most evident on those questions in which application of scientific principles is required.

Conclusions

One may conclude justifiably from the evidence here presented that the training of student teachers in science tends to be specialized, and it would seem that they do not possess the knowledge of subject-matter sufficient to teach science courses outside their special fields. Further, the emphasis in the training of student teachers in science seems to be placed more upon the learning of factual information than upon the ability to apply scientific principles.

Recommendations

Insofar as the results of this study are valid, the following recommendations seem worthy:

1. That further study be undertaken to determine whether the implications of this study are applicable also to student teachers in science and "majors in science" in high schools other than those participating in this study when various tests of subject-matter competency are employed.
2. That further study be undertaken to determine the type of training in science which may be desirable for remedying the inadequacies here indicated.

GYPSUM PLASTER FOR FIRE PROTECTION

Gypsum plaster, with the mineral vermiculite instead of sand as an aggregate or filler, is claimed to give from two to four times the fire protection provided by ordinary sand plaster.

Vermiculite itself is literally fireproof because it can not be ignited under any condition. It is light in weight, is widely used in lightweight concrete and plaster and has several other important applications. As found in nature, it is heavy. But when subjected to a heat treatment, it expands permanently to about 16 times its original volume. It is the expanded vermiculite that is used in the plaster.

Vermiculite is chemically a complex hydrated aluminum-iron-magnesium-silicate mineral. It is mined in Montana, Wyoming, Colorado and North Carolina. A huge deposit in Wyoming, in which mining operations started recently, is said to contain several million tons.

SEMI-LOGARITHMIC AND LOGARITHMIC GRAPHING FOR INTERMEDIATE ALGEBRA STUDENTS

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The war years accelerated the motivation of the teaching of mathematics, thus making it easy to convince pupils of the desirability of acquaintance with this great branch of human knowledge. The armed services promoted the study of mathematics to such an extent that it seemed to the teachers for a while that argument with the young student about the advantages of effort and time spent in the study of mathematics was no longer necessary. Young women trained in mathematics suddenly found many commercial concerns welcoming them into their organizations to fill the void left by the young men who had transferred their energies to Uncle Sam's business.

The time has come, however, when the mathematics teacher has of necessity diminished the war applications, and injection of a greater number of peacetime uses is imperative. Applications must be of more general interest and broader in scope. The fundamental principles of mathematics taught in our schools do not change, but applications shift radically from time to time. Think of the shift from the old wood cord and wall paper days to international exchange and drift angles! Except for the occasional student who revels in mathematics for its own sake, the majority of pupils see our subject as a live one chiefly through the applications of the mathematical principles learned. A very small percent of the students in high school mathematics classes will specialize in the subject as such, but there are many others, particularly among the gifted of our population, who can use mathematics indirectly, if only to make straighter thinking possible in the fields of business, sociology, economics, and biology.

It is the opinion of the writer of this article that our high-grade, well-staffed high schools are doing a very satisfactory job of equipping the student who intends to major in mathematics for the sheer love of it and also the student who knows his future work will depend largely on mathematical knowledge. Perhaps we are neglecting the large part of the population who will not use the techniques and manipulations of mathematics in their future living but can become more intelligent citizens if they learn to think mathematically, learn to read statistical tables more critically, and are taught to be aware of certain quantitative patterns which permeate living in general in modern society. An individual with a keen mind, if he is to read and converse intelligently, should appreciate such items as the normal dis-

tribution curve with its impact on many situations, the power behind the compound interest formula if the time element is great, and the difference between the actual and percentage change in a time series. Such knowledge enhances his joy in living and affords him some protection also. Furthermore, society in general requires that individuals be well informed if it is to survive with any degree of grace.

The purpose of this paper is to present a plan for the teaching of the simplest of semi-logarithmic and logarithmic graphing to intermediate algebra classes in high schools. A convenient time for this venture is during, or at the close of, the work on logarithms. It can be done well by about a third of the students taking intermediate algebra in a school of satisfactory standards. In schools where ability grouping is practiced, all members of the faster classes can master this material. If there is no sectioning according to ability, the best students can carry it as supplementary work. True, it will take some class time to direct these good students, but time taken for the project need not hurt the conscience of the teacher. Too long we have tried to pour all students into one mold, the hypothetical average. This procedure is not fair or wise for the gifted in a group. Naturally, devoting a little class time for the benefit of the mentally vigorous alone will be a bit wasteful for the pupils at the lower end of the mental scale, but much more time is usually spent for the good of the slow in the heterogeneous class as it is. Therefore it is only fair to allot some time specifically to the excellent students. While good students are mastering a bit of this topic, the conscientious among the average will gain in appreciation of the powers of mathematics. This gain cannot be tested but is there nevertheless.

The following definite procedure was evolved and practiced in accelerated classes with the purpose in mind of teaching the bare essentials of logarithmic graphing at the expense of a minimum of time. False moves are costly; therefore, specific plans are very necessary.

Since progressions have not been studied by the typical intermediate class before logarithms are presented, the terms "sequence," "series," "arithmetic progression," and "geometric progression" are defined, with special emphasis on the progressions. The students are instructed to continue each of the following for three or more terms: $3, 4, 6, 7, 9, \ldots$; $1, 2, 3, 5, 8, \ldots$; $3, 5, 7, 9, \ldots$; $\frac{1}{2}, \frac{1}{4}, \frac{1}{8}, \frac{1}{16}, \ldots$. An arithmetic progression is a sequence of numbers each of which equals the preceding number plus a constant, d. A geometric progression is a sequence of numbers each of which equals the preceding number multiplied by a constant, r. A class can identify the two progressions in the above list; then it is ready to complete several more progressions for practice work. It is unnecessary to make examples difficult at this time because we are not teaching progressions as

such. In the progression $\frac{1}{2}, \frac{1}{4}, \frac{1}{8}, \ldots$, we have one of Galton's ideas on heredity. He thought the influence of ancestors upon each individual is indicated by this progression. According to this progression what influence did Galton think an ancestor six generations back would have? (Note: Mendel refuted Galton's theory. Mendel's law exhibits the laws of probability, and while very interesting and strictly mathematical, this is not the place for such a study.)

After this little introduction to simple progressions is given, the following problems are assigned:

TABLE 1

$\log_2 1 =$	$\log_{10} 1 =$	$\log_3 1 =$
$\log_2 2 =$	$\log_{10} 2 =$	$\log_3 3 =$
$\log_2 4 =$	$\log_{10} 4 =$	$\log_3 9 =$
$\log_2 8 =$	$\log_{10} 8 =$	$\log_3 27 =$
$\log_2 16 =$	$\log_{10} 16 =$	

Now observe relations between numbers, bases, and logarithms in each of the three columns in Table 1. Conclusions: If the bases are alike and the numbers form a_____progression, then the logarithms form an_____progression. Is the converse true?

Next, three types of graph paper are given to each member of the class, two sheets of rectangular paper, two of semi-logarithmic paper, and one of logarithmic paper.* It is better not to allow a group to supply even its own rectangular paper because (a) papers must be carefully selected to fit problems assigned, or the reverse, and (b) when a comparison is made of curves from the same data on both rectangular and semi-logarithmic paper, the horizontal axes should be scaled alike.

The diagram of Figure 1 is duplicated and handed to the students. The solid lines represent material given to the student and the dotted lines are those supplied by him. In this figure, the points of division on both axes are equally spaced, but the numbers applied on the horizontal axis are the logarithms from the first column of Table 1 and the numbers attached to the vertical axis are the corresponding numbers. However the *numbers* on the vertical scale are coupled with the same *numbers* on the horizontal scale. Note points A, B, C, etc. First the student draws a smooth curve through points A, B, C, etc. Vertical lines are erected to the horizontal axis at points where lines were omitted on the original chart. These lines are extended upward until terminated by the curve. Then from these intersection points, horizontal lines are drawn to the vertical axis. Note: the horizontal axis

* Satisfactory papers are two sheets of number 358–62, two sheets of 358–6, and one sheet of number 358–110, all printed by Keuffel and Esser and available in packages of 25.

has the successive points of equal division labeled in A. P. while the vertical axis has the series of original points labeled in G. P. Semi-logarithmic paper can be sketched in this fashion, or one can use the logarithmic table to determine the divisions on the vertical axis.

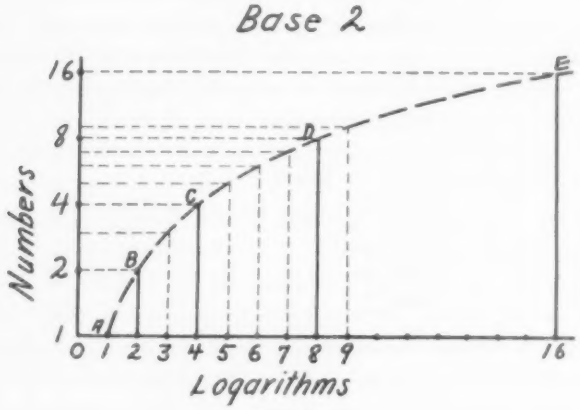

FIG. 1

Next we are ready for a study of the printed semi-logarithmic paper in hand. The horizontal axis is arithmetic in its divisions, matching the rectangular paper exactly. But the vertical axis is a logarithm scale of two cycles. We notice that actual numbers are printed on the vertical scale, starting with 1, and each number is followed by dashes. See Figure 2. The first 1 can represent any power of 10. If the first 1 represents 1, the second 1 is 10, followed by 100 for the third 1. Whatever value is assigned to 1 at the base of the vertical axis, the next higher 1 is 10 times the first and the following 1 is 10^2 times the first. If several cycles are shown, the power of 10 is increased 1 for each new cycle added. These digits on the logarithmic scale CANNOT BE SHIFTED. A slice cannot be cut off the graph paper horizontally and a new start be made indiscriminately. The numbers on the printed sheet must be adhered to or distortion will result. In this sense semi-logarithmic graphing is quite different from rectangular charting. A 1 can be placed anywhere on the vertical axis of a rectangular sheet and the numbering be continued from there. The divisions are all equal. As a matter of interest, the student compares the distance from 1 to 2, 1 to 4, 1 to 8, and 1 to 16 on the vertical axis of semi-logarithmic paper. The cube of 2 is 8 and to cube a number, the logarithm of the number is multiplied by 3. The distance from 1 to 8 is three times the distance from 1 to 2. This is not surprising because the vertical axis is logarithmically spaced.

Let us proceed with the problems.

"Problem 1. (See Figure 2). Using logarithms and the compound

interest formula, compute and form a table of values for \$3000 for 14 years at 6%, compounded annually. All years need not be computed. (Mechanical work can be reduced by distributing the log work among members of the class for home work and listing the results the

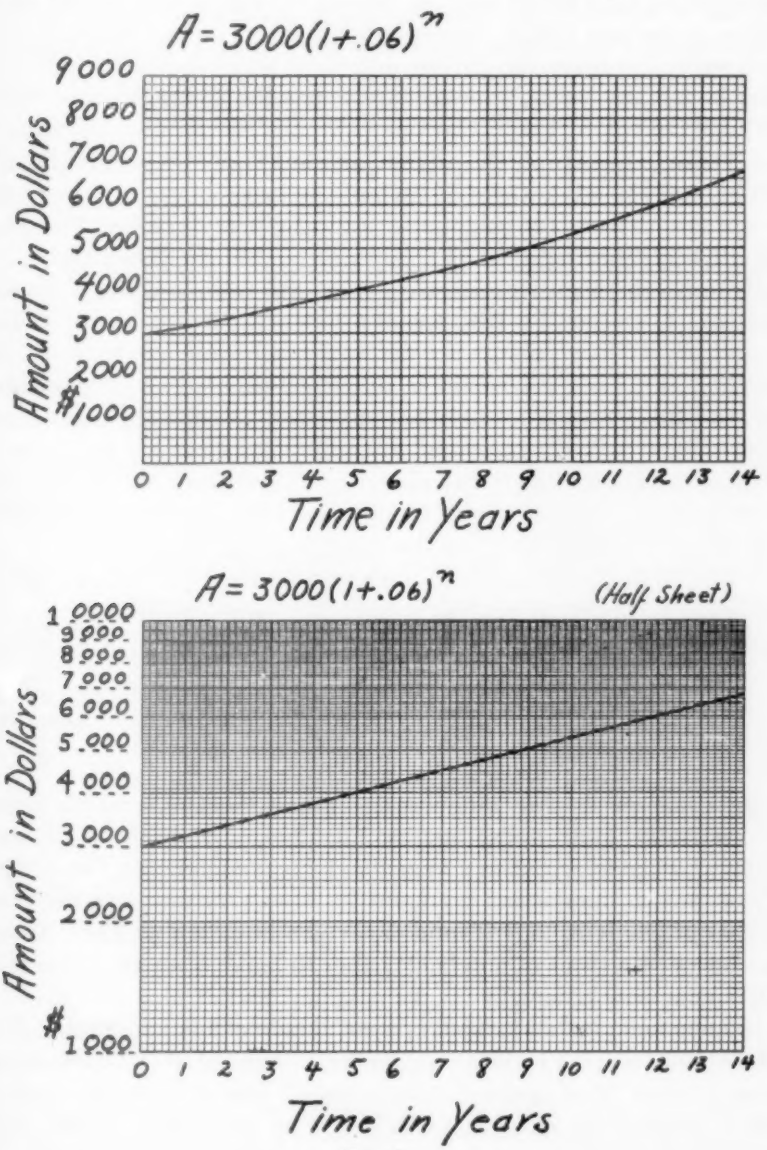

FIG. 2

next day.) (A) On the vertical axis of the rectangular paper, let each main division represent \$1000; on the horizontal axis, each main di-

vision is one year. Plot the data from the table; then draw a smooth curve through the points. By a horizontal cut, eliminate the part of the paper not in use. (B) Cut off one cycle of the two-cycle semi-log paper and plot the same data as on the rectangular paper, the vertical axis starting with \$1000 and the horizontal axis labeled in the same way as in the first graph. Assemble both charts on one sheet of notebook paper, compare the curves, and write any conclusions you can. After how many years, approximately, has the \$3000 doubled itself? Without benefit of graph can one estimate the number of years it would take to quadruple the original amount under these conditions?"

What are the advantages of each of the types of graph paper? disadvantages? The rectangular paper indicates *actual* change. The semi-logarithmic paper helps us to study *rate* of change. When the line is straight on the semi-logarithmic paper, the rate of change remains constant. Therefore, for the type of problem studied in the preceding paragraph, only two points are necessary to enable one to graph the function. Interpolation is simple on either paper, but extrapolation is more readily and accurately accomplished on the semi-logarithmic paper since it is easier to extend a straight line than a curved one. If every year's amount were calculated from 0 through 14 years in this problem, what kind of progression would these figures for amounts form? Why is there no zero on the logarithmic axis?

"Problem 2. (See Figure 3.) Two small business firms, A and B, showed gains in equity for four consecutive years as follows:

TABLE 2

	Capital	End 1st yr.	End 2nd yr.	End 3rd yr.	End 4th yr.
A	\$1000	\$1080	\$1166.40	\$1259.71	\$1360.49
B	500	550	605.00	665.50	732.05

Using a half sheet of rectangular and a half sheet of semi-log paper, cut vertically, graph these figures. Each major division on the horizontal axis can be taken as 1 year. Each large division on the vertical axis of the rectangular can represent \$100, and the first 1 on the vertical axis of the semi-logarithmic paper can be taken as \$100. Mount the charts on a sheet of notebook paper to make comparisons simple. Write your conclusions."

Judging from the rectangular paper, business A is apparently doing better than business B. In actual increase, A is ahead of B. But actual growth is not what interests the investor; rate of increase concerns him. Company B has accomplished more according to the semi-logarithmic graph. It has done better per dollar invested. Herein lies many a mistaken notion about investments. For example, if one wishes to compare two stocks on the stock market as to their growth over a period of time, unless they start at the same price, one should sketch

the figures on semi-logarithmic paper to determine their relative growths. This is the reason one finds the semi-logarithm chart in many technical financial periodicals. Business people refer to this type chart as the percentage chart.

What is the explanation of the phenomenon observed in the preceding problems? Both problems exhibit a sequence of numbers of the

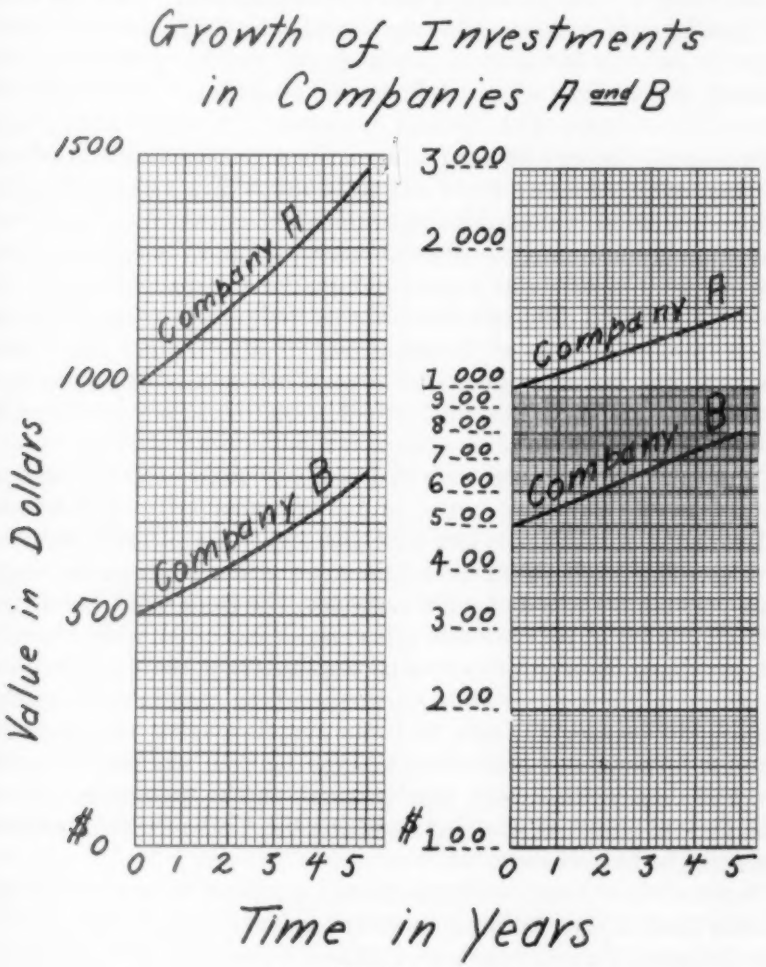

FIG. 3

same type, a geometric progression. In problem 1, $r=1.06$. In problem 2, r can be determined by finding the quotient of any term divided by the preceding term since the graph is a straight line on the semi-log paper. The formula which gives the last term of a geometric progression is $l=ar^{n-1}$. $(a, ar, ar^2, ar,^3 \cdots ar^{n-1})$ The compound interest formula is $A=p(1+r)^n$. These two formulas are essentially alike.

Note that the variables are underlined. Following are other examples whose equations, graphed on semi-logarithmic paper, form a straight line. (1) "If P is the pressure of the atmosphere, measured by the number of inches of mercury which the atmosphere can support, and if h is the height above sea-level in miles, then $P=29.9\times10^{-.0869h}$. Calculate (a) the pressure at sea-level; that is, where $h=0$; (b) the pressure 5 miles above sea-level." Plot the curve on semi-logarithm paper, using these two points. Then read from the chart the pressure for various levels above the earth's surface. (2) "The healing of a certain wound follows the equation $A=107\times10^{-.0221t}$, where A is the area of the wound in square centimeters after t days. What should the area be after 4 days? Suppose that in an actual case the area of the wound turned out to be much larger than the calculations indicated it should be? Assuming the equation to be correct, what conclusion would you draw about the wound?" Graph the equation on semi-logarithmic paper and read the expected size of the wound for several different days. The preceding quoted problems are taken from page 364 of *Introduction To Mathematics* by Cooley, Gans, Kline, Wahlert. There are several other interesting examples on this page, the mere reading of which is quite instructive even when no attempt is made to solve them.

Now all the examples referred to previously are of the type $y=ab^x$, an exponential equation and often called the *growth formula*.

Given the formula, $y=ab^x$, take the logarithm of both members. This gives $\log y=\log a+x\log b$, a linear equation in $\log y$ and x, a and b are constants and x and y are variables. The slope is $\log b$ and the y-intercept is $\log a$. We note that one variable is simple, while the other is logarithmic. In $A=p(1+r)^n$, A corresponds to y; therefore, it should be placed on the log axis while n corresponds to x, and consequently is laid on the rectangular axis. It is not surprising that the compound interest formula and others of this type become straight lines when graphed on semi-log paper, the "y-term" on the vertical or log axis, and the "x-term" on the rectangular axis. Under these conditions, the straight line is inevitable.

Some of these better students cannot grasp the theory of this topic at this level in their training, but the explanation does take it out of the category of a magician's trick. Then, there are a few who are carried beyond the stage of mere appreciation into the realm of mastery. However, generally all of the students do learn that (1) semi-logarithmic paper shows rate of change rather than actual differences, (2) if the equation is of the form $y=ab^x$, two points will determine the graph on semi-logarithmic paper, (3) if statistical data from practically a straight line on semi-logarithmic paper, the equation can be written from the graph using coordinates of two of its points in the general

equation, and (4) if percentage increase is high, the curve often extends beyond the rectangular paper while semi-logarithmic paper can accommodate figures from the very small to the extremely large.

Any student who has carried through problems 1 and 2 as stated above and who has become conscious of the four conclusions in the preceding paragraph, has something to add to his store of knowledge. However, these results constitute only a part of what can be accomplished by some high school students studying this topic. From the standpoint of general education alone, it should be pointed out that $y=ab^x$ is called the growth formula for a very good reason. Population figures follow approximately this formula when a given community is allowed to expand normally. Knowing this, city engineers can predict what will be needed in the line of public facilities for several years in advance. The utility companies can likewise plan. True, a city must have been in existence long enough to have established a definite pattern of growth or predictions will necessarily be less reliable. The growth of a plant, such as a corn stalk, follows this same curve until it reaches a certain stage of maturity. Figures for the complete growth pattern when graphed on rectangular paper produce a curve quite like an integration sign. The tapering off of the curve in connection with these biological examples is caused by the fact that there is a definite limit to size set by heredity. Normal business follows the growth curve. When biology, business, sociology, and economics are all touched by this law, it is reasonable to assume that knowledge of this growth formula and attendant peculiarities should help our students to read the papers and magazines a bit more acutely. It is pleasant to realize that a bright student can be made aware of these things if he never studies mathematics beyond the third year in high school.

The very superior student can travel much farther with this topic with a minimum of instruction. The problem about the healing of the wound, referred to earlier, is interesting and challenging because of the negative exponent. Our township high school serves four villages of unequal sizes. Questions have arisen in classes about their comparative rates of growth. To answer the question, one year two students from each village visited the respective village halls and secured population data, graphed the census figures on both rectangular and semi-logarithmic paper. Then a committee placed the figures for all four villages on one single sheet of each type of paper. The curves were nearly "parallel" on the semi-logarithmic paper but diverged greatly on the rectangular paper as the years increased. All showed the communities reaching a state of maturity because of the tapering off from 1930 to 1940. A large rate of increase turned up in one village about 1910 and was out of pattern. A resident of the village explained

that the village limits were extended at that time. The high school enrollment figures were charted for rate of growth and the curve appeared to be very much like the composite graph of the four villages. It was necessary to use three-cycle paper to care for two of the villages which fact was not surprising because, like compound interest, when they gain a little momentum, they advance rapidly. Then one young man who was interested in geography was not satisfied with local findings. He visited the Chicago Public Library and secured figures and graphed population data for Illinois, Cook County, and Illinois outside Cook County. These specific figures would not be of general interest, but they certainly were to the class involved. A similar plan could be carried out in any part of the country, however, and it is good training for the students to visit their city officials and libraries.

If some student is still not convinced that a person can be grossly misinformed by improper selection of graph paper for a given study, let him chart the figures for the Dow-Jones yearly highs in industrials, rails, and utilities for the years 1940 through 1947. Here are the figures:

TABLE 3. YEARLY HIGHS OF DOW-JONES AVERAGES*

	1940	1941	1942	1943	1944	1945	1946	1947	1948 to Oct. 19
Industrials	152.80	133.59	119.71	145.82	152.53	195.82	212.50	186.85	193.16
Rails	32.67	30.88	29.28	38.30	48.40	64.89	68.31	53.42	64.95
Utilities	26.45	20.65	14.94	22.30	26.37	39.15	43.74	37.55	36.04

* Courtesy of Harris, Upham & Co., Brokers, Chicago, Illinois.

When charted on rectangular paper, the industrials appear to fluctuate more than the others. Actual differences are greater. However, these same figures placed on semi-logarithmic paper show that the industrials have been subject to less fluctuation, dollar for dollar. Again let us remind ourselves that the investor is interested in the rate of change, not actual change.

"Problem 3. (See Figure 4.) Take a half sheet of rectangular and a half sheet of logarithmic paper, both cut vertically. Using the horizontal axis to represent r in both cases, graph the equation $A=\pi r^2$, from $r=0$ through 6. Assemble the two graphs side by side on a sheet of notebook paper. Can you draw any conclusions?"

"Problem 4. Using the same directions as in problem 3, plot $V=e^3$."

The equations of problems 3 and 4 are of the general type, $y=ax^b$, where again x and y are variables and a and b constants. This is known as the power formula. Take the logarithm of both members and we have: $\log y=\log a+b \log x$. This is a linear equation in $\log y$ and $\log x$, the slope being b and the "y-intercept" $\log a$. Since both

variable are logarithmic, it is natural that this linear in log y and log x should produce a straight line on logarithmic paper. Other equations of this type are these: $F = m \cdot m'/d^2$, the force between two magnetic poles d distant apart; K.E. $= \frac{1}{2}mv^2$, the kinetic energy formula. There are many other such formulas.

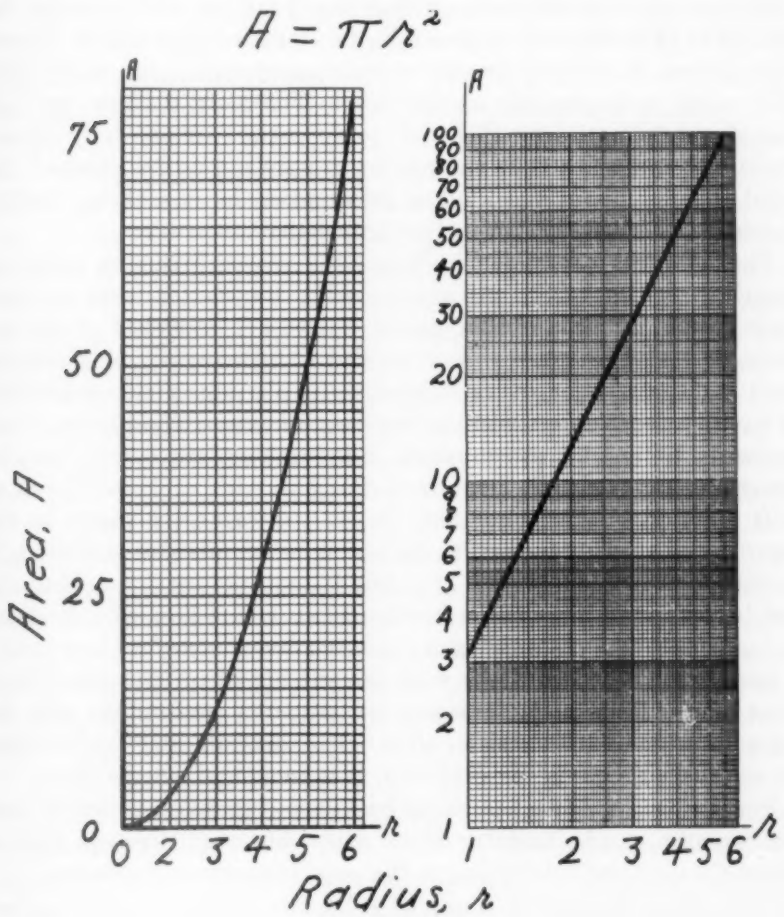

FIG. 4

The advantages of the logarithmic paper are (1) an equation of the type of the power formula will form a straight line on log paper; therefore, merely two points are necessary to draw the curve; (2) if statistical data give an approximate straight line on the log paper, the equation can be calculated from two of its points.

It is true that individuals who continue their studies of mathematics and science will meet all of the material above at some later date, but the time is not wasted for them because the second con-

sideration of any topic tends to fix the essential ideas more easily and permanently.

We, as teachers of mathematics, like to think that students who continue their efforts along scientific lines are quite bright, but, is the converse necessarily true? No! A majority of the capable pupils in a random selection will not continue much farther than through the third year of mathematics offered in the standard high school. Therefore, we owe it to these people to make mathematics as meaningful and useful as is possible at this level. The alert student has had enough mathematics by this time to appreciate, if not fully understand, the sad truth that one can be grossly misled by charts if his mind is fuzzy about the kind of information he is seeking, and he should be afforded this protective knowledge.

The following expression indicates the reason given for omitting practical applications in the mathematics courses. Oh, that precious class time! The main outline above can be accomplished at the expense of very little class time if carried simultaneously with regular work and spread over several days. Careful planning makes it possible to have students do most of the work out of class and adds but a few moments to regular assignments. False moves are costly; concise directions are essential. Definite warning should be given (1) not to shift units on a logarithmic axis and (2) to watch the count on the logarithmic scales because of the changing number of divisions as lines become closer together. If a child is confused by these points, he had better spend his time on fundamentals where he probably needs it, but the bright children take these inconveniences in their stride. A good start has been made with the subject of progressions which must be met later in the semester, the students are familiar with the log scale which is the basis of slide rule operation, and the students are enthusiastic about log-graphing. It is fresh and new to them.

Perhaps our non-mathematical friends will grow up to admit that mathematics can be useful to those whose life work does not make a direct demand on its techniques. We need their moral support.

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THE DYNAMIC NATURE OF GEOGRAPHY

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Napoleon once said, "The policy of state is in its geography." Jules Cambon, the famous French diplomat once declared that, "The geographical position of a nation is the principal factor conditioning its foreign policy—the principal reason why it must have a foreign policy at all." Sir Halford Mackinder, one of the most noted geographers once wrote, "The great wars of history are the outcome, direct or indirect, of the unequal growth of nations, and that unequal growth is not wholly due to the greater genius and energy of some nations as compared with others; in large degree, it is the result of the uneven distribution of fertility and strategical opportunity upon the face of the globe." These quotations are only three among many which emphasize the outstanding importance of geography in peace and in war. Whenever a war breaks out we immediately become exceedingly conscious of the value of geographical knowledge and understanding. We should be equally aware of the importance of geographical knowledge and understanding in helping us to secure and maintain a worthwhile peace. That is the problem facing us today and that is the reason we should consider the dynamic nature of modern geography.

Geography is dynamic—never static. It is always new and *the dynamics of geography makes history.* The average person thinks of geography first of all in terms of location. Geography does emphasize location or global relations. Location means knowing *where* places are in *living relations* to one another, that is, their global relations. Let us take Magnitogorsk, a modern Soviet city on the eastern slope of the Ural Mountains, as an illustration. It is at 53 degrees, 10 minutes north latitude and 59 degrees, 10 minutes east longitude. That is its mathematical location on the surface of the earth, but what is the significance of its location? One significant fact is that it is within four miles of one of the largest and richest iron ore deposits in the world—Magnetnaya Mountain which has an iron content of 60 per cent. It is on the Ural River which supplies water and power for the steel mills. The Kizil coal field is within 250 miles and the Karaganda field less than 1,000 miles. Manganese, nickel, chromium, and other mineral deposits are in the same general area.

Twenty years ago on that site was a small village of nomadic herdsmen. They were interested only in the pasturage for their animals in the Ural River valley and on the slopes of the Urals. The city rose in the short space of three or four years when the Soviet Union decided to develop the Magnetnaya Mountain iron deposit and to build iron

and steel centers in the interior of the Soviet Union at a safe distance from its western borders. Here at Magnitogorsk was a strategic site—near a huge deposit of excellent iron ore, an ample water supply, and not too far from coal, other necessary alloy minerals nearby, far in the interior and the topography such that transportation facilities could be developed.

The story of Magnitogorsk—a modern city of over 250,000 people—illustrates the *dynamic nature of geography*. The iron ore deposit existed for countless ages, but it had no meaning to the nomadic herdsmen. The grass had meaning: it meant food for their animals, and the animals provided them with food and clothing. When the engineers from Moscow came into the Urals, the mountain of iron ore had significance to them because of their technical knowledge. They saw in the small Ural River a supply of water for the mills, and by damming the river, a source of power. Thus the physical environment of the Urals had an entirely different meaning to the Russian engineers than it had for the nomadic herdsmen. The whole landscape has been changed. "The lonely open steppe has come to life, and where the nomads of yesterday pastured their flocks trains loaded with coal and iron ore journey to and fro from Kuznetsk, and great black furnaces rise in the midst of rolling open country." Today children of those nomads now work somewhere in the vast Magnitogorsk Combine which covers an area of 27 square miles in the Ural River Valley.

This story also illustrates how the *dynamics of geography makes history*. The heavy industry developed in the Urals which began in 1929 with Magnitogorsk was the determining factor in the Soviet Union's ability to resist the Germans in World War II, hold them on the Moscow-Stalingrad line, and eventually force them to retreat. Today, it is a vital factor in the settlement and development of western Siberia.

Thus the geography of any region changes as man's knowledge of the region increases and as he discovers new ways of using the resources of a region. A new instrument of power such as the airplane, a new chemical, or a new use for a well-known resource may mean a new geography. Consider the change in the geography of northern Canada which man's use of the airplane has made; new towns, mines, oil wells, pipe lines, numerous types of human activity where only a few years ago was a wilderness known only to the Indian and the fur trapper.

Man's inventions have frequently given new meaning to fixed physical-geographic facts. In doing so they have transformed the political, economic, and cultural patterns of the world and of world relations. The steam engine was one such invention when it was applied to drive factory wheels, ships, and trains. The internal-combus-

tion engine when applied in motor vehicles and in the airplane is another. These two inventions and the long chain of technical developments which grew out of them are the bases of modern industry, modern transportation, the modern city, the modern type of nation-state.

Even such a simple act as carrying a plant to another land may change the geography and the history of that land. The introduction of the potato into Europe changed the geography of Germany and Ireland. It was well-suited to the damp cool climate and the soil of those two countries. It supplied the necessary food for a tremendous growth in population. In Germany this population furnished the manpower for industrial power and also for military power. The rest of the story you know. In Ireland the population grew, then a blight struck the potato crop, famine stalked the land, emigration followed,—the Irish immigrant helped to build America.

The introduction of the hevea rubber tree into Malaya and the East Indies is another illustration of the dyanamic nature of geography. It resulted in the introduction of the modern plantation system, caused the shifting of population, developed equatorial forested areas, increased the value of these areas to European nations. It made available a cheap and reliable supply of rubber which is essential to the motor vehicle industry. The ramifications of that incident comes on down through World War I and II. As Dr. Isaiah Bowman says, "Each plant breeding success means the reappraisal of our climatic boundaries, soil types, and cultivation techniques."

Man lives on the earth. He is conditioned by the physical conditions of the region in which he lives. However, both he and nature are constantly making changes in the physical environment and those changes have repercussions—frequently world-wide in their scope—both in the present and on to the future. That is why geography is dynamic.

Now, to turn to the problem which we as teachers face: How can we make the dynamic nature of geography a reality to the student?

To give reality to anything outside a student's immediate environment necessitates firing his imagination with vivid images which have an emotional drive that will cause the student to think and act from a global viewpoint. Vivid dynamic images are the means by which men's visions are directed and their loyalties are determined. Cecil Rhodes, a sick weak student seeking health, found South Africa mostly a wilderness. He not only made men know South Africa as it was, but he transformed men by injecting into them his own visions of what he believed South Africa could become. The South Africa of today to a large extent is the result of Cecil Rhodes' power to lead men to share his visions.

Another example of the power of vital images went almost unnoticed during the World War II. Soon after Hitler invaded Russia, Stalin dropped all reference to Communism and the Soviet State. Instead, all proclamations and directives to the Russian people called upon them to defend their fatherland—Russia. The individual Russian loves his own land probably more than any other people except the French peasant. The following refrain from a popular Russian song expresses the deep feeling of the Soviet people towards their land:

> "From great Moscow to the farthest border,
> From our Arctic Seas to Samarkand
> Everywhere man proudly walks as master
> Of his own immeasurable Fatherland."

Stalin was referred to as the *father* of his people, the protector of the land. And it was not until these images, personifying patriotism and love of homeland were revived that the Soviet people responded with energy.

What images of our own land are we giving our students? Are they static images of forest or dynamic images of men using the forests and reforesting as they cut? Are they static images of flat or rolling landscape or dynamic images of changing farmlands and of soil conservation? Do the students actually see in their mind's eye the grandeur of Niagara, the Grand Canyon, the majesty and beauty of the Rockies, and the quieter but nonetheless inspiring beauty of our eastern mountains? Are our cities mere dots on a map to our students representing a conglomeration of stone, steel and cement, or do those dots call up images of roaring factories and mills, of busy people working and playing?

Do our students think of Africa in terms of cacao, palm oil, copper, gold, diamonds? Or do they see the varied peoples of that great continent struggling to fit themselves into a modern world by improving their agriculture, fighting soil erosion, studying to eradicate disease and improve their cattle, building roads, schools, and hospitals. In short, in Africa there is a dynamic society trying desperately to use the environment so as to have a better living and to fit into the modern world society.

What kind of images are we developing in our students to direct their visions and loyalties? Through what kind of concepts and images are we shaping their thinking? Are we helping them to see the new and dramatic world patterns based on interdependence of nations and peoples?

Geography teachers have an unrivaled opportunity to build such images, concepts, and attitudes, but they must select and organize materials to that end. Also they must use techniques which will

dramatize and fix the desirable images, concepts, and attitudes. In short, you must teach *dynamic geography*.

THE COOPERATIVE COMMITTEE MEETING IN NEW YORK

The Cooperative Committee for the Teaching of Science and Mathematics of the American Association for the Advancement of Sdience is sponsoring three symposia at the annual meeting of the Association in New York City.

On Tuesday, December 27, at 10 A.M. in the Grand Ballroom of the Hotel New Yorker a forum will be held on: *Trends in Modern Science* (K. Lark-Horovitz, chairman; Department of Physics, Purdue University, Lafayette, Indiana): Laurence Quill (Department of Chemistry, Michigan State College, Lansing, Michigan), "The Correlation Between the Properties of the Rare Earths and the Trans-Uranium Elements"; Lincoln V. Domm (Whitman Laboratory of Experimental Zoology, University of Chicago), "Trends in Hormone Research"; E. C. Stakman (Department of Agriculture, University of Minnesota, Minneapolis, Minnesota), "Trends in Research in Agriculture."

The second symposium will be held on Thursday at 1:30 P.M. on Science in General Education: Earl McGrath (Commissioner on Education, U. S. Office of Education), "The Program of Science Teaching in General Education"; Paul B. Sears (Department of Botany, Oberlin College, Ohio), "Science and Concord"; Morris Meister (The Bronx High School of Science, New York City), "Scientific Literacy—What Is It?"; K. Lark-Horovitz, "Summary."

The third symposium, following immediately after the second, the Improvement of the Science Instruction on the College Level (E. C. Stakman, chairman): speakers, J. B. Conant (President, Harvard University); W. F. Loehwing (Department of Plant Physiology, University of Iowa); Fernandus Payne (Department of Zoology, Indiana University); Alan Gregg (Division of Medical Education, Rockefeller Foundation).

For a detailed announcement of the total program of the teaching societies affiliated with the AAAS, please refer to the special program of the teaching societies available either from the AAAS in Washington or Dr. Karl Lark-Horovitz at Purdue University.

GEIGER COUNTERS MEASURE DEPTH OF SNOW

Geiger counters are now being used to measure snow depths in Western mountains.

This technique was reported by Walter Wilson of the U. S. Weather Bureau at a symposium on mass and heat transfer from snow, lakes and ground surfaces held at the University of California at Los Angeles.

Actually the snow itself is not radioactive, but a bit of radioactive cobalt placed beneath it is. By recording how much the clicking of the Geiger counter decreases or increases, the depth of the snow bank can be accurately determined.

Mr. Wilson, a member of the Weather Bureau's snow-investigating team which worked last winter in the High Sierra, said that the Geiger counter technique was the most successful of six methods of measurement employed.

Snow was an important item on the agenda of the two-day conference, sponsored by the U.C.L.A. engineering department. This was because, as Mr. Wilson indicated, mountain snow packs are the "primary sources" of Western rivers which supply many Pacific Coast cities with water.

The need for increasingly accurate methods of measuring evaporation and runoff was stressed. Without more accuracy in this respect, prediction of available water supply for Western cities is an uncertain affair, he pointed out.

RADAR AS A RESEARCH INSTRUMENT

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From time to time in the history of science there have come discoveries which have been valuable not only in themselves but because they have served as means for the accomplishment of further discoveries. The telescope and microscope and the principle of spectroscopy are important examples. We have been accustomed to think of the development of radar as the process of perfecting a device for utilitarian purposes of navigation and communication. Actually it may have far-reaching value as a research instrument. It is now being used extensively for research in astronomy, chemistry, and physics, to mention but three broad areas.

It is difficult to determine when radar had its origin, as it is a special application of the principles of radio. About 1890 Hertz produced radio waves in the laboratory. These had previously been predicted on a theoretical basis by Maxwell, who showed that light waves are electromagnetic and that longer waves of the same nature should be producible by electrical methods. Radar waves are simply radio waves of shorter length than is used for ordinary radio work. They are often referred to as microwaves.

Radar involves the principle of reflection of these waves from some opaque object back to the source. It was observed in 1922 that some radio energy was reflected back to the transmitter by a ship passing between the transmitter and receiver of a radio set-up.[1] The principle of reflection has been widely developed, but microwaves have been substituted for the longer waves because they travel in straight lines rather than following the earth's curvature and hence act according to optical laws.

It was found necessary to use special types of tubes for radar transmitters as the radio tubes of customary design do not give sufficient power to send microwaves far enough. The magnetron and klystron tubes were developed for this purpose.

There are three types of radar which differ in the way in which reflected waves can be received at the point of transmission without interfering with the waves that are still being transmitted. Obviously waves cannot be continuously received at the same frequency as that of waves which are being continuously transmitted. There must either be a change in frequency or an intermittent system of reflection and transmission. The three types are known as:[1]

[1] *The Cathode Ray Tube and Typical Applications.* Allen B. DuMont Laboratories, Instrument Division, Clifton, New Jersey, 1948.

1. c-w or continuous wave.
2. Frequency modulation.
3. Pulse modulation.

The c-w type is useful only when being reflected by a rapidly moving object. It involves a Doppler change in frequency caused by motion of the object toward or away from the source. The velocity of the moving object can be determined by the degree of change of frequency of the reflected wave.

The pulse modulation, which is the type most widely used, involves an intermittent transmission of radio energy as pulses of 1 to 50 microseconds in duration. After each pulse has been transmitted the antenna is disconnected from the transmitter and connected to the receiver in time to catch any return of the transmitted signal. The antenna is then switched back to the transmitter in time for the next pulse to be sent out. A cathode-ray tube is used with the receiver to indicate the time interval between pulse transmission and return. It is thus possible to ascertain the distance of the object that reflected the wave.

In frequency modulation, the transmitter sends out waves that vary in frequency continuously and periodically. The frequency of energy received will correspond to that of energy transmitted slightly earlier and can be distinguished from that which is being transmitted at the moment of reception. The time lapse can be determined from the difference in frequency. This method is suitable for a stationary target but is complicated by a superimposed Doppler frequency change if the target is moving toward or away from the observer.

The wartime use of radar in the determination of both velocities and distances of ships and aircraft would seem to suggest its use in making similar determinations on such astronomical bodies as the sun and moon. This has been done in the case of the moon in order to get more accurate values of velocity and distance. It is planned to make similar measurements on the sun. The radar waves go to the moon and back in about $2\frac{1}{2}$ seconds, the same time necessary for light to make the round trip. It will take 16 minutes before a return signal is heard from the sun. The first moon determinations were made in September 1945 by the Army Signal Corps Engineering Laboratories under the direction of Lt. Col. DeWitt.[2] This was "project Diana." The pulse system was used. Pulses of one quarter second of a frequency of 1.115×10^8 cycles per second were transmitted. The receiver was made highly selective so that extraneous noises could be tuned out. The moon's velocity toward or away from the earth can be determined by a Doppler shift in frequency of the return wave which may be as large as 300 cycles per second. The antenna system

[2] Mobenson, Jack. "Radar Echoes from the Moon," *Electronics*, Vol. 19, No. 4, Arpil 1946, pp. 92–98.

was 40 ft square and supported on 100-ft towers; it was so mounted that it could be controlled in azimuth but not in altitude. Since there was no altitude control, observations were limited to times of moonrise and moonset. Completely controlled antennas will no doubt be available for this work in the future. The distances now measured are accurate to within a few thousand miles.[3] It is expected that equipment for measuring distances to within a mile will be made available. Radio waves of broadcast frequency cannot be used for such studies as they will not penetrate the ionosphere. It is clear that studies of the ionosphere itself can be made with radar.

The ionosphere is now known to contain several layers of ionized gases. Primarily there are three layers:[3] the E layer about 70 miles above the earth; the F_1 layer extending up to about 130 miles above the earth; and the F_2 layer at about 250 miles. The highest layer is always present[4] although subject to daily and seasonal fluctuations, but the lower layers tend to form with the beginning of sunlight and disappear after dark. The ultraviolet light from the sun is believed to be responsible for producing the ionization of these layers. The layers are opaque to radio waves of lower frequency than 10^7 cycles per second.[5] These include the broadcast frequencies, which are reflected back to the earth. Frequencies above 10^7 cycles per second are transmitted by the ionized layers, although the limiting frequency which is passable depends upon the extent of ionization and will be lowest just before sunrise when the ionization is least. There is no upper limit to the frequencies which can pass the ionosphere, but the use of frequencies above 3×10^{10} cycles per second in astronomical work is prevented by an opacity due to molecular absorption bands in the earth's atmosphere.[5]

Extensive astronomical studies are now under way by Cornell University, the National Bureau of Standards, and the Naval Research Laboratories, to mention only those in the United States. The frequency range between 10^7 and 3×10^{10} cycles per second will be covered in these investigations. Already some surprising facts have been learned. That the sun and stars are continually sending us some energy in these frequencies is perhaps not unexpected, as these radio waves differ only in frequency from the visible light which we are receiving. We might even have expected the enhanced solar noise which is associated with sunspots and prominences. But the cosmic noise has so far defied any theory for a consistent explanation.[5] This cosmic noise, or galactic noise, seems to come particularly from two regions in the Milky Way, the Sagittarius region producing the

[3] Menzel, Donald H. "Radar and Astronomy," *Astronomical Society of the Pacific Leaflet No. 217, March 1947*, San Francisco, Calif.

[4] *Science News Letter*, Vol. 54, No. 20, Nov. 13, 1948, p. 318.

[5] Burrows, Charles R. "Radio Astronomy," *Scientific Monthly*, Vol. 68, No. 5, May 1949, pp. 299–304.

maximum noise and the Cygnus region somewhat less. There are, however, a number of tiny regions or "point sources" which radiate large amounts of radio energy.[5] No explanation is yet available for this phenomenon. It has not been decided whether certain unusual stars are responsible for the galactic noise or whether it results from the atomic activity in some nebulous areas of hydrogen gas near hot stars, or even from dust particles in the space between the stars.

The studies of solar and galactic noise do not strictly involve the radar principle but were mentioned because radar wavelengths are used and because they resulted from the development of radar receiving equipment.

The radar principle is utilized, however, in the study of meteors. The trail of ionized air left by a meteor in the upper atmosphere enables one to obtain two types of reflection phenomena which are detectable by radar.[6] Bursts occur when radar waves are reflected from the side of the path of ionization. When reflection comes from the front of the advancing path of ionization, the return frequency will experience a Doppler shift and will produce beats with the original transmitted frequency. A so-called "whistle" will be produced by these beats. Bursts are best studied when the transmitting and receiving stations are about 100 miles apart.[6]

In the field of meteorology, radar promises to be a most useful instrument. It has been used to detect storms for at least 6 years.In September 1945 the Florida hurricane was studied.[7] The eye of the storm was found to contain no precipitation as it produced no radar echoes, and was 12 miles in diameter. Observations were made from a distance of 10 miles. Storms can be studied up to distances of 150 miles or more if they extend far enough vertically into the atmosphere.[8] The range is 175 miles for a storm extending 20,000 ft vertically, 120 miles for one which extends 10,000 ft and 8 miles for a 5,000-ft storm. Even greater ranges are possible with airborne radar.

The laws governing the reflection of electromagnetic waves from water are not altogether understood but it is known that the strength of the echo depends upon both the mass of water and size of drops.[8] Thus the strength of echo generally indicates the severity of the storm. High frequencies are especially desirable for the detection of precipitation as water is more transparent to the lower frequencies. A wavelength of 3 cm has been found advantageous. Radar can be used to detect showers, squall lines, thunderstorms, cold fronts, warm fronts, occluded fronts, typhoons, hurricanes, and tornadoes.

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[6] Manning, Laurence A. "The Theory of the Radio Detection of Meteors," *Journal of Applied Physics*, Vol. 19, No. 8, August 1948, pp. 689–691.

[7] *Science*, Vol. 102, Oct. 26, 1945, Sup. p. 14.

[8] Maynard, Commander R. H., U.S.N. "Radar and Weather," *Journal of Meteorology*, Vol. 2, No. 4, December 1945, pp. 214–215.

Not only will water produce a reflection of radar waves but a region of atmosphere with a sharp change in dielectric constant will do the same.[9] This enables one to determine air-mass boundaries and other atmospheric discontinuities. At present, upper-air characteristics are obtained by a few radiosonde observations and subsequent changes followed by radar. Drastic changes can then be checked by later radiosonde observations. It has also been suggested that radar stations be placed between those where radiosonde observations are made to supply data for interpolation in order to make the weather map more accurate.

The speed and direction of the wind at various altitudes can be ascertained by sending up free balloons and following their paths by reflected radar waves.[10] Such balloons may be covered with special reflecting surfaces if desired. Barometric methods of altitude determination can be dispensed with in such cases. Radar will make it economical for more thorough three-dimensional weather studies to be made.

Maurice Brooks of West Virginia University plans to use radar to study the height and speed of flight of migrating birds.[11] In the case of wild geese and other large birds, it may be possible to actually identify the birds as well as to observe the flight. During the war, birds became a nuisance to radar operators. They were detected as early as 1941 in England and later in the United States.[12] With the introduction of higher-powered transmitters in 1943, they became such a nuisance on the British Coast that operators had to be especially trained to distinguish between the birds and aircraft or ships. At least one invasion alarm was sounded in England as the result of birds being detected but erroneously identified on a radar screen. Major Ramsay demonstrated that birds could produce radar echoes by suspending a herring gull from a captive balloon.[12] The echo from the bird was clearly distinguishable on the screen from the balloon echo.

Just as chemical elements can be detected by observing the light emitted or absorbed by them through a spectroscope, so can they be detected by using high-frequency radio waves. It has already been mentioned that waves of radar frequencies are emitted by the sun. The distribution of frequencies will depend upon the condition and nature of the emitting or absorbing material. Emission microwaves may be of value in thermal radiation measurements, as was determined by Southworth in 1945.[13] He found that some noise is produced in the high-frequency receiver by black-body radiation.

[9] Friend, Albert W. "Developments in Meteorological Sounding by Radio Waves," *Journal of the Aeronautical Sciences*, Vol. 7, No. 8, June 1940, pp. 347–352.

[10] Hauck, V. P., Cosby, J. R., and Dember, A. B. "Radiosonde Telemetering Systems," *Electronics*, Vol. 19, No. 5, May 1946, p. 123.

[11] *Science*, Vol. 101, March 30, 1945, p. 329.

[12] *Nature*, Col. 156, No. 3963, October 13, 1945, p. 446.

For microwave spectroscopy as a method of chemical identification, however, emission spectra are not used as they are masked by the temperature radiation from nearby objects.[14] Absorption spectra are used exclusively for this purpose. It was discovered during the war that atmospheric gases absorb certain radar wavelengths. The microwave spectroscope was then developed at the Research Laboratory of Electronics at the Massachusetts Institute of Technology.[15]

The microwave absorption spectra will, among other researches, be useful in certain biological studies using tracer isotopes which are not radioactive. Such isotopes that eventually find their way to the skin, hair, or nails can be detected by removing a small sample and placing it in the path of the microwaves to produce an absorption spectrum.

In the use of any new research tool, the possibility of danger to the operators should not be overlooked. A Navy doctor, Lt. Comdr. Daily, has studied the effects of radar on 45 men.[16] He has found some flushed faces and mild headaches, which disappeared when the men were kept more than 4 ft from the antenna or transmitter. No evidence of any lasting physical damage has been discovered, but it is recommended for safety that radar personnel be shielded from the apparatus and be subjected to periodic physical examinations.

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[13] Pollard, Ernest C., and Sturtevant, Julian M. *Microwaves and Radar Electronics*. Wiley, New York, 1948, p. 390.

[14] Kikucki, C., and Spence, R. D. "Microwave Methods in Physics. 1. Microwave Spectroscopy," *American Journal of Physics*, Vol. 17, No. 5, May 1949, p. 289.

[15] *Science News Letter*, Vol. 54, No. 9, Aug. 28, 1948, p. 140.

[16] *Newsweek*, Vol. 22, July 26, 1943, p. 72.

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ON COURSES IN PHYSICAL SCIENCE FOR ELEMENTARY SCHOOL TEACHERS

STANLEY W. MORSE
San Francisco State College, San Francisco, California

In recent years the education departments of many teacher training institutions have gone all out for "Workshops" in education and in the various subject fields taught in the elementary schools. They have social studies workshops, music workshops, art workshops, and science workshops as well as workshops designed to give training or practice in the integration of the various subjects in the elementary school situation. The workshop movement is in the direction of laboratory instruction rather than lecture-demonstration teaching and is to be commended. However, the idea is not a new one since a somewhat similar plan has been employed in a number of places within the subject fields. San Francisco State College has offered science courses for teachers of experience for some number of years, the work being a part of the program of the Natural Science Department. The example cited here was a course offered in the August Post Session of '41.

The problem: Elementary school teachers need summer school work in physical science for a number of reasons; among them: (a) they are placed in a teaching situation where work in physical science is expected in the program, (b) they hold old or temporary teaching credentials and must meet a science requirement for renewal, (c) they want an A.B. degree and must meet a basic science requirement, (d) they are interested in science, (e) they prefer to earn units for salary increments in science rather than in some other area.

At the same time most teachers want upper division units rather than lower division units. Many of the teachers lack sufficient background in the physical sciences to do the work in standard upper division courses.

Most elementary school situations lack equipment usually deemed necessary for instruction in the physical sciences and have little or no funds available for the purchase of even the simplest of equipment.

These various problems were considered and a unit developed in order to meet as many of them as possible in the time available. The result was the course called "Applied Science and Invention for Elementary Schools."

The nature of the course: Applied Science and Invention for Elementary Schools was a two semester unit block of work given for a period and a half six days per week for three weeks. It was assigned an upper division number because of the method of instruction to be

used rather than because it presupposed a knowledge of the physical sciences. The work was planned for experienced elementary school teachers, but permission was given for four college students with practice teaching experience to take the course. A total of fifteen made up the class. One of the teachers had been a physical science major, the others had little formal science training or had had it some years previous.

The plan of instruction was to simulate a common elementary school situation: (a) a teacher who knew little about physical science but who wanted to include some in her program, (b) there was no special provision in the classroom for science work, (c) there was no equipment, (d) there was no money for the purchase of materials. However, in this situation, there were books on science for children that could be obtained from the "county" library including the "*Science Guides for Elementary Schools*" published by the State of California.

During the first week, the instructor outlined possible uses of the physical sciences in the elementary school program, demonstrated ways in which everyday materials could be used, and constructed science equipment from cardboard, wooden boxes, "tin" cans, and miscellaneous glassware. At the same time teacher background was developed regarding electrical circuits, basic concepts of energy, and of machines. Reading was assigned in the Science Guides and other elementary source materials. These assignments were to enable the students to select the area of physical science in which they were to specialize, the basic idea being that time was too short for each student to develop all fields but each could become a "specialist" in one small area, at least for purposes of the elementary school program.

The results of the work of each student and of the instructor were dittoed and given to each member of the class.

The majority of the students selected and began work on their special area before the end of the first week, the rest early in the second week. The second week was devoted to individual work by the students in reading for background, in assembling the materials to be used, and in building the equipment necessary for their project. The room was kept open all afternoon for the students' use and was very well patronized. Simple tools, hammers, saws, drills, screw drivers, tin shears, soldering iron, scissors, a vise, and "C" clamps were provided, mounted on a tool board such as is usually recommended for school use.

The last week was taken over by the students who presented their work to the class, including the description of the constructing of the equipment, teacher background required, and the recommended procedure for using the projects at some specific elementary level.

Some of the developments were: a complete weather station with weather vane, anemometer, wet-dry bulb thermometers, rain gauge, and barometer, for use in the 5th grade; magnetic toys including dolls, rocking horse, and crane for kindergarten; electromagnets, telegraph, microphone, principles of the telephone, doorbells, and motors for various grades; simple machines; studies of heat, expansion, freezing, boiling, evaporating and cooling, radiation, conduction, convection including convection heating; sources of sound, musical instruments, conduction, identifying direction of a sound; studies of power including several types of water wheels. Chemistry happened to have been neglected in this particular class although in more recent classes, it has been included along with light, astronomy, geology, and mineralogy.

Evaluation of the work:

Each student was asked to fill out the following sheet in order to evaluate the effectiveness of the method. The numbers in the blanks are the numbers of students checking the space. In some cases one or two students did not check each item. The term "impurity" was used during the work for the non-experienced members of the class since the class was designed originally for experienced teachers.

"Evaluation of Course"

Do not sign this sheet. Are you one of the "impurities" in this course? (4)
Please express your candid opinion regarding the following. (Mark X in the proper space)

A. Before this course my information regarding:

	large	*fair*	*small*	*very small*
Weather stations, methods, etc.	0	7	1	7
Electricity and its appliances	1	2	3	8
Machines	1	2	4	7
Heat and heating	2	5	2	5
Sound	2	4	4	4
Water power	0	1	5	7

B. My increase in information during the course regarding:

	large	*fair*	*small*	*very small*
Weather stations, methods, etc.	6	7	1	0
Electricity and its appliances	8	3	2	1
Machines	5	7	1	1
Heat and heating	3	7	1	2
Sound	5	4	3	1
Water power	3	9	0	1

C. Read all of C before answering any.

Was the method of conducting this course, this is, throwing the individual almost completely on his own resources, satisfactory? Yes *15* NO *0*

Did this method resemble a situation that might have arisen in your actual teaching situation? (2 impurities, 1 teacher not voting) Yes *11* NO *1*

Did the result of the study you made change your feeling toward approaching any science problem that might arise in your teaching? (1 impurity not voting) Yes *14* NO *0*

If so, did it result in increased confidence in your ability to meet a science problem? (1 impurity not voting) Yes *14* NO *0*

Would you prefer in a similar course you might have to take to have it conducted by the instructor through demonstrations, assuming that the instructor was competent and knew the elementary school situation? (1 not recorded said "some of each") Yes *3* NO *11*

Do you believe that *others* taking a similar course would profit more if examinations were given *in addition* to the student reports? (1 not recorded said "depends on person") Yes *5* NO *9*

Do you believe that *others* taking a similar course would profit more if examinations were given *without* the student reports? (the 1 not voting voted yes on the above) Yes *1* NO *13*

Do you think that the construction activities were of real value rather than a waste of time? Yes *15* NO *0*

D. Remember this was a 2 unit course. Rank the amount of time you put in on this course compared with your average 2 unit course in summer or post session. (An "impurity" voted "less").	*More*	*About same*	*Less*
	4	10	1

E. Rank the following courses from the viewpoint of a teacher required to take physical science courses. Mark the most suitable 1 point, the least 6 points, etc.

Like this, on the "mechanical-inventive"[1] nature	*25 pts.* (1)
Like this, on the "manipulative-assembling"[2] nature	*32 pts.* (2)
Like this, combining the 2 (must be 6 weeks)	*42 pts.* (4)
On the identification of common rocks and minerals	*57 pts.* (5)
On the basic science ideas behind and the care and repair of science materials in the home	*29 pts.* (3)
On the practice and theory of photography with emphasis on its use by the teacher in the school.	*63 pts.* (6)

Note 1: "Mechanical-inventive" was used to indicate construction and development work without supplied specific directions or equipment.

Note 2: "Manipulative-assembling" was used to indicate the conducting of experiments according to supplied directions with equipment supplied.

F. Do you think a practical course in visual instruction[3] would go over in summer or post session? (1 impurity not voting) Yes *14* NO *0*

Note 3: The answer is interesting in view of the recent requirement of a minimum of 2 semester units in "audio-visual aids to instruction" recently established by the State of California for all credentials.

G. How are you satisfied (not knowing your grade) with your experiences in this course?

Very well satis.	*Well satis.*	*Satis.*	*Fairly satis.*	*Not satis.*
9	5	1 (impurity)	0	0

Four voluntary statements were written on the questionnaire:

1. "I like the course very well—most encouraging—built up my confidence."
2. "I am very well satisfied despite my grade. Thank you!"
3. "I have learned in a more satisfactory way to myself than *any* college course I have ever taken. I was thrown on my own resources to discover by actual experience yet received enough encouragement and help to continue. In other words, the course not not so bookish that it deprived me of the pleasure of personal discovery. Am coming back to take more physical science."
4. "Very well satisfied, new to me, practical and useful in my grade."

In an oral discussion with the one "impurity" who had a physical science background, he volunteered the statement that he certainly profited a great deal in his adjustment to the elementary school science level.

The results of this experience lead us to believe that more of this type of work should be offered by the science staff. Recent experiences have confirmed this belief. Every science staff in a teacher training institution needs to have on it and probably does have specialists in elementary school science. They should see to it that other members who work with prospective elementary school teachers have experiences working with summer school classes consisting of experienced teachers. The effects of such an experience will be valuable and should have a beneficial effect upon the science training program for prospective teachers.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve his readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

Late Solutions

2139. *Walter L. Smith, Long Beach, Calif.*

2142. *Francis L. Miksa, Aurora, Ill.*

2144. *Ronald Henderson, Pine Mountain, Ky,*

2149. *Proposed by Norman Anning, University of Michigan.*

Show that one of these equalities is an identity and solve the other.

$$\sin x \sin 4x + \sin 2x \sin 5x = \sin 3x \sin 6x$$

$$\sin x \sin 4x + \sin 2x \sin 7x = \sin 3x \sin 6x.$$

Solution by A. MacNeish, Chicago

(a) Solution of equation. By well known formula:

$$\sin x \sin 4x+\sin 2x \sin 5x=\sin 3x \sin 6x$$
$$-\tfrac{1}{2}(\cos 5x-\cos 3x)+(-\tfrac{1}{2})(\cos 7x-\cos 3x)=-\tfrac{1}{2}(\cos 9x-\cos 3x)$$
$$\cos 5x-\cos 3x+\cos 7x-\cos 3x=\cos 9x-\cos 3x$$
$$\cos 5x-\cos 3x=\cos 9x-\cos 7x$$
$$-2 \sin 4x \sin x=-2 \sin 8x \sin x$$
$$\sin x(\sin 4x-\sin 8x)=0$$
$$\sin x=0$$
$$x=n\cdot 180^\circ$$
$$\sin 4x-\sin 8x=0$$
$$\sin 4x-2 \sin 4x \cos 4x=0$$
$$\sin 4x(1-2 \cos 4x)=0$$
$$\sin 4x=0$$
$$4x=n\cdot 180^\circ$$
$$x=n\cdot 45^\circ$$
$$1-2 \cos 4x=0$$
$$\cos 4x=+\tfrac{1}{2}$$
$$4x=n\cdot 360^\circ\pm 60^\circ$$
$$x=n\cdot 90^\circ\pm 15^\circ.$$

Therefore, $x=n\cdot\pi$, $x=45^\circ\cdot n$, $x=n\cdot 90^\circ\pm 15^\circ$, for n integers.

(b) Identity

$$\sin x\cdot \sin 4x+\sin 2x \sin 7x=\sin 3x \sin 6x$$
$$-\tfrac{1}{2}(\cos 5x-\cos 3x)+(-\tfrac{1}{2})(\cos 9x-\cos 5x)=-\tfrac{1}{2}(\cos 9x-\cos 3x)$$
$$\cos 5x-\cos 3x+\cos 9x-\cos 5x=\cos 9x-\cos 3x$$
$$\cos 9x-\cos 3x\equiv\cos 9x-\cos 3x.$$

Other solutions were offered by: C. W. Trigg, Los Angeles City College; W. J. Blunden, St. John's, Nfld.; Gerald Sabin, University of Tampa; B. Felix John, Philadelphia, Pa.; W. R. Talbot, Jefferson City, Mo.; John Q. Taylor King, Austin, Texas; and the proposer.

2150. *Proposed by W. R. Talbot, Jefferson City, Mo.*

The hypotenuse of a primitive right triangle of integral sides becomes the base for a larger primitive right triangle of integral sides. This process may be repeated any number of times. If the first triangle meets the condition imposed on the subsequent triangles, show that the area of any of these triangles is 6 times the sum of the squares of the first n integers, where n is the largest integral square root in half the unrepeated side of the triangle.

Solution by the proposer

Being integers, the sides of the right triangle are given by the formulas for Pythagorean triples; i.e. $x=a^2-b^2$, $y=2ab$, and $z=a^2+b^2$ where a and b are integers. For primitive triangles a and b are of different parity, and thus x and z are odd. Then in the next triangle, z must become x. From the identity

$$\left(\frac{z+1}{2}\right)^2-\left(\frac{z-1}{2}\right)^2=z$$

we see that $a'=(z+1)/2$ and $b'=(z-1)/2$ lead to the desired form for x' of the next triangle. From $a'=b'+1$, we must have $a=b+1$, since the first triangle must be of the form of the subsequent ones. The formulas for the sides of the

original triangle become $x=2b+1$, $y=2b(b+1)$, and $z=2b^2+2b+1$. From the formulas for a' and b', we get $a'=b(b+1)+1$ and $b'=b(b+1)$ or, in terms of a and b, $a'=ab+1$ and $b'=ab$. Similarly for the next triangle, $B=a'b'$ and $A=a'b'+1$. As an example, consider this last triangle for which $x=A^2-B^2$, $y=2AB$, and $z=A^2+B^2$. The area is $AB(A^2-B^2)=B(B+1)(2B+1)$ since $A=B+1$. The latter expression for the area may be recognized as the sum of the series $1^2+2^2+\cdots+n^2$ where $n=B$, the largest integral square root in $B(B+1)=y/2$.

The formula for the sum of the series is easily obtained from the identity

$$n^3-(n-1)^3=3n^2 \quad -3n \quad +1.$$

Replace n by $n-1$

$$(n-1)^3-(n-2)^3=3(n-1)^2-3(n-1)+1$$

Similarly,

$$(n-2)^3-(n-3)^3=3(n-2)^2-3(n-2)+1$$

Finally,

$$1^3- \quad 0^3=3(1)^2 \quad -3(1) \quad +1.$$

If S_2 denotes the sum of the squares and $S_1=n(n+1)/2$ denotes the sum of the arithmetic series, upon adding the columns, we get $n^3=3S_2-3S_1+n$ from which $S_2=n(n+1)(2n+1)/6$.

Solutions were also offered by: C. W. Trigg, Los Angeles City College; Francis L. Miksa, Aurora, Ill.; and W. J. Blundon, St. John's, Newfoundland.

2151. *No solution has been offered to this problem which was likely incorrectly stated.*

2152. *Proposed by Orville F. Barcus, Philadelphia.*

What value of n will make $n^2+324n+307=r^2$, where r is an integer? Is there a general solution?

Solution by C. W. Trigg, Los Angeles City College

$$n^2+324n+307=r^2$$
$$n^2+324n+26244=r^2+25937$$
$$(n+162)^2-r^2=25937$$
$$(n+162+r)(n+162-r)=25937\cdot 1=701\cdot 37.$$

$n+162+r=25937$	$n+162+r=701$
$n+162-r=\quad 1$	$n+162-r=\ 37$
$r=12968$	$r=332$
$n=12807$	$n=207$
$n+162+r=-25937$	$n+162+r=-701$
$n+162-r=-\quad 1$	$n+162-r=-\ 37$
$r=-12968$	$r=-332$
$n=-13131$	$n=-531$

Reversing the matching of the algebraic and arithmetic factors gives the same values of n but changes the signs of the corresponding values of r. Thus there are four values of n and eight solutions of the given equation.

In general, the equation $n^2+2kn+p=r^2$, which may be written in the form $(n+k)^2-r^2=k^2-p$, will have four times as many solutions as there are pairs of factors of k^2-p, provided that in each pair the factors are both odd or both even. If k^2-p is a perfect square, then for the factor pair, $\sqrt{k^2-p}\sqrt{k^2-p}$, $r=0$, and there are only two solutions.

Other solutions were also offered by: W. H. Cleveland, Meridan, Miss.; W. R.

Talbot, Jefferson City, Mo.; Francis L. Miksa, Aurora, Ill.; P. L. Howe, Angwin, Calif.; W. J. Blundon, St. John's, Newfoundland; Roy Wild, University of Chicago; and the proposer.

2153. *Proposed by William L. Schaaf, Brooklyn.*

Derive a formula for the area of a segment of a circle in terms of the height, h, and the length, w, of the chord.

Solution by V. C. Bailey, Evansville College

The area of a segment of a circle is given by the well known formula

$$\text{Area} = 1/2r^2(\theta - \sin\theta)$$

$$\theta = 2 \arctan \frac{4wh}{w^2-4h^2}$$

$$r = \frac{w^2+4h^2}{8h}$$

$$\sin\theta = \frac{8wh(w^2-4h^2)}{(w^2+4h^2)^2}$$

$$\text{Area} = \frac{(w^2+4h^2)^2}{46h^2} \arctan \frac{4wh}{w^2-4h^2} - \frac{w}{16h}(w^2-4h^2).$$

Other solutions were also offered by: C. W. Trigg, Los Angeles City College; W. J. Blundon, St. John's, Newfoundland; Gerald Sabin, University of Tampa; Francis L. Miksa, Aurora, Ill.; and W. R. Talbot, Jefferson City, Mo.; and W. R. Smith, Sutton's Bay, Michigan.

2154. *Proposed by W. H. Cleveland, Meridian, Miss.*

Show that $3^{2n}+7$ is divisible by 8.

Solution by W. R. Talbot, Jefferson City, Missouri

We notice that $3^{2n} = 9^n = (8+1)^n = (\text{Multiple of } 8)+1$. Adding this to $7 = 8-1$, we obtain the desired divisibility.

Other solutions were offered by: Norman Anning, University of Michigan; Roy Wild, University of Chicago; Eugene Jamison, Columbia, Mo.; P. L. Howe, Angwin Calif.; Walter L. Smith, Long Beach, Calif.; J. W. Lindsey, Amarillo, Texas; Francis L. Miksa, Aurora, Ill.; B. Felix John, Philadelphia, Pa.; C. W. Trigg, Los Angeles City College; W. J. Blundon, St. John's Newfoundland; J. Slavin, Brooklyn, N. Y.; Ronald Henderson, Pine Mountain, Ky.; W. R. Smith, Sutton's Bay, Michigan; and the proposer.

HIGH SCHOOL HONOR ROLL

The editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

2153. *William Sherwood, Clyde Lindner, Fred DiMaio—all of Red Bank High School, Red Bank, New Jersey.*

2154. *David Freeman, Union High School, Mill Valley, California.*

PROBLEMS FOR SOLUTION

2167. *Proposed by Philip Maclasky, Philadelphia.*

In any triangle, the mid-point of a side, the mid-point of the segment joining

the vertex opposite this side to the point of tangency of the in-circle with the same side, and the in-center, are collinear.

2168. *Proposed by V. C. Bailey, Evansville, Indiana.*

In triangle ABC, if $c=b+\frac{1}{2}a$, and BC is divided at D so the $BD:DC::1:3$, prove that $\angle ACD=2\angle ADC$.

2169. *Proposed by Robert E. Horton, Los Angeles, California.*

Give the circle $x^2+y^2=a^2$ and its involute which starts at the point $(a, 0)$. Locate the x and y intercepts of the involute.

2170. *Proposed by C. W. Trigg, Los Angeles City College.*

Theorem: The square of the perpendicular dropped from a point on a cord of a semi-circle to *the* diameter equals the product of the segments of the diameter less the product of the segments of the chord.

2171. *Proposed by Ruth Poultius, Mobile, Ala.*

If the bisector of angle A, of triangle ABC, meets BC at D, show that

$$AD=\frac{2bc}{b+c}\cdot\cos\frac{A}{2}.$$

2172. *Proposed by Clara Lane, Chevy Chase, Md.*

In any plane triangle ABC, if

$$\tan\frac{A}{2}=\frac{5}{6} \quad \text{and} \quad \tan\frac{B}{2}=\frac{20}{37}.$$

Show that $a+c=26$.

BAUSCH & LOMB SALES AIDE PROMOTED

Appointment of Kenneth E. Reynolds as Manager of Analytical Instrument Sales at Bausch & Lomb Optical Company was announced Aug. 5, 1949. He succeeds Charles C. Nitchie, who retired after 19 years with the optical firm.

A former Physics instructor at Illinois Institute of Technology, Reynolds joined Bausch & Lomb in 1937. During the war he was in charge of special government contracts for aerial mapping equipment, and in 1947 became Assistant Manager of the firm's Photographic Lens Sales Department.

An authority on aerial mapping techniques, he was elected to the board of directors of the American Society of Photogrammetry two years ago.

Nitchie, who graduated from Cornell University, was chief chemist at the New Jersey Zinc Company before joining Bausch & Lomb. An expert in the field of spectrography, he was instrumental in developing several Bausch & Lomb spectrographic instruments, including the large Littrow spectrograph.

Snow remover to clean walks will clear a 16-inch path in snow up to 12 inches in depth, throwing the snow as much as 25 feet to one side. It is two-wheel affair, with rubber tires and equipped with a 1.5-horsepower gasoline engine, and is guided by a handlebar from the rear.

Electric hone, for use in homes, factories and on farms, will sharpen tools from kitchen knives to garden hoes without burning blades or grinding them away. Plugged into the household electric socket, it employs what the makers called a magnetic honing action, without use of wheels or gears.

BOOKS AND PAMPHLETS RECEIVED

ORGANIC CHEMISTRY, by G. Bryant Bachman, *Professor of Chemistry, Purdue University*. Cloth. Pages x+432. 14.5×23 cm. 1949. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York 18, N. Y. Price $4.25.

PLANE GEOMETRY, by William G. Shute, William W. Shirk, and George F. Porter, *Instructors in Mathematics, The Choate School, Wallingford, Connecticut.* Cloth. Pages viii+406. 14×21.5 cm. 1949. American Book Company, 88 Lexington Avenue, New York 16, N. Y.

BIOLOGY, by Frank M. Wheat, *Chairman, Department of Biology, George Washington High School, New York, N. Y.*, and Elizabeth T. Fitzpatrick, *Principal, Bay Ridge High School, Brooklyn, N. Y.* Cloth. Pages xxxvi+571. 14.5×20 cm. 1949. American Book Company, 88 Lexington Avenue, New York 16, N. Y. Price $3.40.

PRINCIPLES AND PRACTICE IN ORGANIC CHEMISTRY, by Howard J. Lucas, *Professor of Organic Chemistry, The California Institute of Technology, Pasadena, Calif.*, and David Pressman, *Associate Member, the Sloan-Kettering Institute for Cancer Research, New York City.* Cloth. Pages xi+557. 15×23 cm. 1949. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $6.00.

SCIENTIFIC AUTOBIOGRAPHY AND OTHER PAPERS, by Max Planck. Cloth. 192 pages. 13.5×21 cm. 1949. Philosophical Library, 15 E. 40th Street, New York 16, N. Y. Price $3.75.

GENERAL CHEMISTRY: A SYSTEMATIC APPROACH, by Harry H. Sisler, *Formerly of The University of Kansas, now at The Ohio State University*, and Calvin W. VanderWerf and Arthur W. Davidson, *The University of Kansas*. Cloth. Pages x+870. 15×23.5 cm. 1949. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $5.00.

LABORATORY MANUAL AND PROBLEMS IN GENERAL CHEMISTRY, by A. W. Laubengayer, *Professor of Inorganic Chemistry, Cornell University*. Paper. Pages x+229. 215×28 cm. 1949. Rinehart and Company, Inc., 232 Madison Avenue, New York 16, N. Y. Price $2.25.

GEOMETRICAL TOOLS: A MATHEMATICAL SKETCH AND MODEL BOOK, by Robert C. Yates, Ph.D. Revised. Paper. 194 pages. 20×27 cm. 1949. Educational Publishers, Inc., 122 North 7th Street, St. Louis 1, Mo.

WORKBOOK IN GEOMETRY, by Virgil S. Mallory, *Professor of Mathematics and Instructor in Geometry, State Teachers College, Montclair, New Jersey*, and Zaidee T. Horsfall, *Registrar and Teachers of Mathematics, Queen Elizabeth High School, Halifax, Nova Scotia*. Paper. 176 pages. 20.5×27.5 cm. 1949. Benj. H. Sanborn and Company, 221 East 20th Street, Chicago 16, Ill. Price $1.00.

FUNDAMENTAL ALGEBRA WITH PRACTICAL APPLICATIONS, by Robert L. Erickson, *Professor of Mathematics, Lebanon Valley College*. Cloth. Pages xi+317. 15×23 cm. 1949. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York 18, N. Y. Price $2.80.

HOW YOUR BODY WORKS, by Herman Schneider, *Science Coordinator, New York City Public Schools*, and Nina Schneider. Cloth. 160 pages. 15.5×21.5 cm. 1949. William R. Scott, Inc., Publisher, New York, N. Y. Price $2.50.

CELESTIAL MECHANICS AND METEOROLOGY, by Louis William Flack, Sr., Paper. 18 pages. 20×28 cm. 1949. Louis William Flack, Sr., 3215 E. 7th Street, Kansas City 1, Mo.

LARGE AND SMALL CLASSES IN SECONDARY SCHOOLS, by Ellsworth Tompkins, *Specialist for Large High Schools*. Paper. Pages iv+30. 20×26 cm. 1949. Superintendent of Documents, U. S. Printing Office, Washington 25, D. C. Price 20 cents.

ADULT EDUCATION ACTIVITIES OF THE PUBLIC SCHOOLS. REPORT OF A SURVEY, 1947–48, by Homer Kempfer, *Specialist for General Adult and Post-High School Education*. Pamphlet No. 107. Pages iv+21. 14.5×23 cm. Superintendent of Documents, United States Government Printing Office, Washington 25, D. C. Price 15 cents.

SCHOOL SAVINGS IN THE SOCIAL STUDIES, by Ruth Wood Gavian, Ph.D. Paper. 32 pages. 14.5×23 cm. Copies can be obtained free of charge from State Savings Bonds Offices.

HOW LARGE ARE OUR PUBLIC SCHOOLS, by Walter H. Gaumnitz, Ellsworth Tompkins, Robert C. Story, and Mabel C. Rice. Circular No. 304. Pages v+39. 20×26 cm. Superintendent of Documents, United States Government Printing Office, Washington 25, D. C. Price 25 cents.

WITH LIBERTY AND JUSTICE FOR ALL, by Edna McGuire. Bulletin 1948, No. 15. Pages v+72. 15×23 cm. Superintendent of Documents, United States Printing Office, Washington, D. C. Price 25 cents.

ENCYCLOPAEDIA BRITANNICA FILMS BRING THE WORLD TO YOU. Paper. 44 pages. 21×28 cm. Copies of the New Catalogue may be obtained by writing Encyclopaedia Britannica Films, Wilmette, Ill.

LE RAISONNEMENT MATHÉMATIQUE DE L'ADOLESCENT (THE MATHEMATICAL REASONING OF THE ADOLESCENT) by Louis Johannot. Paper. 174 pages. 15×21.5 cm. Delachaux et Niestlé S.A., Neuchatel, 4, rue de l'Hôpital or Paris VII, 32, rue de Grenelle.

BOOK REVIEWS

OUR SUN, by Donald H. Menzl, Ph.D., *Harvard College Observatory*. Cloth. Pages viii+326. 14.5×21.5 cm. 1949. The Blakiston Company, Philadelphia 5, Pa. Price $4.50.

Here is the latest of the Harvard books on astronomy. It is also one of the best for the general reader of science. A minimum of mathematics is used but it is impossible to tell much about any astronomical body without the use of quantitative terms. The author not only tells much that is known about the sun but explains how much of the information has been obtained. He gives a vivid picture of the great sun spots and the tremendous explosions that frequently occur in the atmosphere of the sun. In the first chapter, *Meet the Sun*, he tells briefly what the ancients knew about the sun and how the distances and mass of the sun are determined. The second chapter tells how to observe the sun and the important things to be seen such as sunspots, prominences, the corona. The next three chapters give some of the important contributions of physics and chemistry to the study of astronomy. Thus far the book has been largely preparatory. Chapter six, *Sunspots—Solar Cyclones*, and all the remainder of the book show the author's real interest. To follow him well more knowledge of physics is important —an understanding of spectroscopy, the Zeeman effect, polarized light, electric and magnetic fields, are necessary to fully understand the discussion given, but the many excellent photographs and drawings will hold the interest of those with less knowledge of science. *The Corona Mystery* is another great chapter, highly illustrated and well discussed. The book closes with an interesting chapter on the

effects of the sun on us: a study of our reserves of coal and oil, direct uses of the sun to supply heat for our homes and energy for our machines, its effect on radio.

This is one of the new science books you should have, both in your school library and in your home.

G. W. W.

ULTRASONICS, by Benson Carlin, Hillyer Instrument Company, Inc., formerly with Sperry Products. Cloth. Pages xi+270. 15×22.5 cm. 1949. McGraw-Hill Book Company, 330 West 42nd Street, New York 18, N. Y. Price $5.00.

With the exception of a relatively few investigators in this country most of the work in the field of ultrasonics has been done in foreign countries. Since the results of individual research here and abroad have not been organized or available this book contributes much to meet the need for information on the subject. One of the outstanding characteristics of the volume is the practical approach to the application of ultrasonics. Much of the material included is the result of the author's own experience in the field. Theoretical discussions are given along with the applied experimental procedures. However, these developments are not complete in themselves but reference is made to sources of complete derivations. While this book does not particularly lend itself to the role of a text it could well serve as a basis for the content of a course in ultrasonics.

The first two introductory chapters deal with the fundamental concepts of high frequency, wave motion, velocity, propagation, energy, methods of production and detection of ultrasonics. Methods of cutting quartz crystals, shapes, modes of vibration, plating, cleaning, testing and crystal combinations are adequately described. Crystal holders employed in exciting solids and liquids, methods of supporting, focusing and coupling are covered in the next chapter. The next two chapters contain a discussion of resonance and reflection with detailed information regarding use in signaling, standing waves, testing and frequency. The use of pulsed ultrasonics in radar, sonar, testing of materials utilizing sweep and delay circuits employing cathode ray tubes is discussed in the next part. Another section is devoted to the general considerations of ultrasonic agitations with reference to power, methods of coupling, dispersion and coagulation, degassing, chemical and biological effects. The final chapter contains a discussion of the practical application of high frequency sound waves and a number of other uses are mentioned in addition to those which are functioning in commercial and experimental applications. The book is well illustrated with excellent diagrams and photographs of equipment; and special references to works of other investigators are made. Adequate information is given for the reproduction of experimental equipment and procedures so that anyone interested will find this book a valuable reference from both practical and theoretical standpoints. The technical language is at a minimum and one not well informed in the field can read it with satisfaction and intelligence.

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HOW TO KNOW THE IMMATURE INSECTS, by H. F. Chu, *Zoologist, Institute of Zoology, National Academy of Peiping, Peiping, China.* Cloth. Pages 234. 21.5×13.5 cm. 631 figures. 1949. Wm. C. Brown Company, Dubuque, Iowa. Price $3.00.

This new addition to the H. E. Jacques nature series introduces a whole new world to nature students. Immature insects not only differ greatly in appearance from adults but also are about seven times as numerous. Until now they have been largely unidentifiable except to specialists.

Pages 1–28 describe immature insects with respect to metamorphosis, importance, appearance, habitat, collecting, and rearing. The main body of the book, pages 28–216, consists of pictured keys to the order and families to which

immature insects belong. Finally, there is a list of important references and a glossary of terms.

All important characters are illustrated at their point of usage in the keys. Some of these illustrations may not be of high caliber, but they serve well the purpose for which they are intended. Most material used in preparing the keys has appeared elsewhere, but never before in as usable a form or in one book.

How To Know Immature Insects is a bold venture into a still new field. It may need revising before a great passage of time, but those who revise it will probably owe their initial interest in and knowledge of immature insects to this very volume.

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BIOMETRICAL GENETICS, by K. Mather, *Head of the Genetics Department, John Innes Horticultural Institution, London.* Cloth. Pages ix+158. 21.5×14 cm. 16 diagrams. 1949. Dover Publications Inc., New York.

Biometrical Genetics covers the subject of continuous variation in genetics. The author, an outstanding geneticist, proceeds under the assumption that the reader already has a knowledge of at least the fundamentals of genetics and statistics. Many volumes on discontinuous variation have appeared since the first awakening to Mendelian principles of inheritance, only a little over fifty years ago. This volume fills the need for a study on continuous variation.

Some of the chapter titles, with an indication of their contents, are as follows: the genetical foundation—biometry, polygenic segregation and linkage, polygenes and major genes; characters—phenotype and genotype, genetic analysis and somatic analysis, the combination of characters; scales—principles, criteria, examples; components of variation—dominance and potence, backcrosses, randomly breeding populations; linkage—effect, test, coupling in barley; number of effective factors—process of estimation, prediction in the presence of linkage, speed of advance under selection; results and concepts—experiments in biometrical genetics, dominance and interaction, and the effective factor. There is also a glossary of the symbols used in the book.

One experiment—on the ear conformation in barley—is published for the first time in this volume, which is definitely for advanced students, teachers, or research geneticists.

GEORGE S. FICHTER

LECTURE DEMONSTRATIONS

A series of articles on *Lecture Demonstration Experiments in Chemistry* is being prepared by Fred T. Weisbruch, McBride High School, St. Louis, Mo. The author invites anyone who has an original idea on lecture demonstration experiments or a new angle on old experiments to correspond with him. Naturally any contribution made will be acknowledged both by name and school of the contributor.

Building material of high elasticity, recently patented, is claimed as a superior product for shingles, wallboards and floor covering because it regains its original shape after being distorted by pressure. It is made of fibrous material blended with aluminum soap and a plasticizer.